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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIII, No. 6 JUNE, 1923 WHOLE No. 197

CHEMISTRY AS A RELATED SUBJECT.[1]

BY PAULINE G. BEERY,

State College, Penn.

THE PROBLEM.

As a representative of the department of chemistry of the Pennsylvania State College, I come to you to discuss the problem of selecting subject matter to be used in the teaching of elementary chemistry to college students, particularly to those students who do not major in chemistry, and who therefore do not expect to engage in the teaching of this subject or in its industrial practice. In our own school, as doubtless in other schools of the university type, by far the greater number of students who come to us for courses in elementary chemistry are not those who expect to go into any phase of chemistry as a life profession. The majority of these students are sent to us from the various schools and departments of the college because of the fact that there is a definite relation between this branch of science and the problems which they will be called upon to meet in their respective professions. During the current year the elementary chemistry course at the Pennsylvania State College has a total enrollment of 1,111. This total number is distributed among the various schools and departments as follows:

Agriculture, total 224.

(General Agriculture 102; Agricultural Education 21; Agronomy 3; Animal Husbandry 12; Chemical Agriculture 7; Dairy Husbandry 7; Forestry 51; Horticulture 19; Poultry Husbandry 2.)

Engineering, total 396.

(Architectural Engineering 28; Civil Engineering 89; Electro-chemical Engineering 14; Electrical Engineering 118; Industrial Engineering 58; Mechanical Engineering 82; Railway Mechanical Engineering 5; Sanitary Engineering 2.)

[1]Editor's note: The above paper, while applying specifically to problems of college chemistry teaching, has such an important bearing upon the theme selected by the Executive Committee of the Central Association for the current year's work ("Laying Foundations for Vocations") that it has been thought wise to print it. Teachers of high school chemistry can read between the lines and apply the findings of the author to their own methods and courses.—*F. B. W.*

Home Economics, total 52.
(General Home Economics 28; Vocational Home Economics 24.)
Liberal Arts, total 254.
Mining, total 68.
Natural Science, total 117.
(Chemistry 17; Industrial Chemistry 37; Pre-medicine 55; Teaching Course in Natural Science 10.)

Of the total number of students with whom we deal in first year work, therefore, only 85, or 7.6 per cent expect to become chemists or teachers of chemistry.

Facing a problem of this sort, a chemistry department must determine what policy it will follow in the treatment of this heterogeneous group of students, and it must adjust its elementary course to fit the needs of the greatest possible number. The department must recognize that, in accepting the task of giving instruction to this group of students with varied interests, it has, as a department, incurred the obligation of making a careful study of the teaching of elementary chemistry, not as an isolated science sufficient unto itself, but as a *related subject*, intricately bound up with a large number of distinctly different fields of endeavor.

As teachers of elementary chemistry we are frequently criticized for failing to recognize this obligation. We mould our courses primarily to fit the needs of those students who are going on in the subject. Because of an engrossing interest in our own limited field we frequently suffer a loss of perspective. Many of us lose sight of the fact that the majority of elementary students are not interested in chemistry for its own sake.

A Consideration of the Possible Types of Elementary Chemistry Courses.

In order to be perfectly fair to all concerned, those having charge of the selection of subject matter for the elementary chemistry courses should make a two-fold study of the problem, as follows: (1) they should map out the possible types of courses which could be presented to elementary chemistry students; and (2) they should make a careful analysis of the needs of the students for whom the course is designed.

Judging from the evidence found in college catalogues, the majority of first year courses in general inorganic chemistry devote the first semester to a study of the non-metals and of general fundamental principles, and the second semester to a study of the metals with an elementary treatment of qualitative analysis. This is likewise the arrangement in our case. The following outline represents the most outstanding variations as

regards method of presentation in the case of a course of this character:

(1) *The Informational Course.*

The course which seeks to show the relations of chemistry to the problems of daily life without going very deeply into fundamental principles, and without employing the use of any great number of signs, symbols, etc.

(2) *The Pre-Vocational Course.*

The course which has the application of chemistry to a specific vocation as the primary feature. In this course the application is made predominant, only that chemistry being taught which is needed to carry the application.

(3) *The Fundamental Course With Adjustable Illustrative Material.*

The course which is deep-rooted as regards its treatment of fundamental principles, but which is made vital by the selection of a wide range of illustrative material so chosen that an individual instructor may give different problems to different types of students.

(4) *The Fundamental Course with Uniform Illustrative Material.*

The course which is deep-rooted as regards its treatment of fundamental principles, but which is made vital by the introduction of well-chosen illustrative material, no differentiation being made between different groups of students.

(5) *The Formal Course.*

The course in which fundamental principles are made the one and only feature, illustrative material being minimized.

The course on the "extreme right" is the purely theoretical, or formal course, the course in which the student is given a thorough drill on fundamental principles, laws, hypotheses, equations, and the like, without linking these conceptions in any way with any experience which he has had or will ever have. An instructor who has a strong tendency toward the extremely conservative wing in discussing this question with me recently stated that he considered it a waste of class-room and lecture time to go into simple applications of the subject, particularly since the student could find most of that material in books, or could figure it out for himself. It is the belief of this instructor, that since he has always had trouble in covering all of the principles which he desires to cover during the time allotted to the course, that the term should be devoted exclusively to a study of pure chemistry. It was probably of teaching of this type that it has been said:

"We teach and teach
Until like drumming pedagogues
We lose the thought that what we teach
Has higher ends
Than being taught and learned."

As a natural reaction to the tendency on the part of many teachers of chemistry to make their science formal and passive, a considerable number of educators of the more modern type have swung to the "extreme left" and have risen up to demand the so-called *informational course*. As given in the outline above,

this term is used to refer to a course which is strictly informational in character, a course which is stripped entirely of signs, symbols, and problems, and which attempts to present the applications of this science to problems of daily life without vexing the student with an intensive study of underlying fundamental conceptions. The exponents of modern educational theory who champion this course recommend it particularly for students of the Liberal Arts courses.

As a course slightly less radical than the strictly informational course, we find Number 2 of the possibilities outlined above, a course with a distinctly *vocational* slant. Demands for elementary chemistry courses applied definitely to a restricted field emanate chiefly from schools and departments of a vocational nature whose chief interest lies in the training of students to follow one specific profession. Those who desire that this be the type of course given in elementary work advocate the grouping of all subject-matter around definite problems of a practical nature, giving in each case only the minimum of pure chemistry needed to "carry" the practical application in question.

Somewhat more liberal than the extremely formal course described above is that which stresses fundamental principles, but which is vitalized by the introduction of illustrative material which will make an appeal to the student by showing him that the science of chemistry is not an isolated subject, but that it has infinite points of contact with his daily experience. This is given above as Course Number (4). According to this plan, no provision is made for adjusting the outside problems or any portion of the laboratory work to the needs of different types of students.

Standing in the center of the group of possibilities is a course which carries with it all of the tradition of the conservatives in that it is based first and last on a belief in the necessity of sound teaching of fundamental principles, but which is colored by the radical wing to the extent that it provides not only for the incorporation of a rich supply of illustrative material but also for an adjustment of various problems to individual interests. In a course of this character the backbone of the course is uniform for all students. The illustrative material (laboratory exercises, outside problems, etc.) is so carefully selected that students with different interests may be given, for a portion of the work, individual problems and laboratory assignments.

The above analysis gives the most distinctive of the colors and shades which are possible in the teaching of elementary chemistry to students of varying interests. The courses mentioned by no means exhaust the possibilities. Like the colors of the spectrum, each blends gradually into the next, with an infinite number of possible intermediate combinations. After making a survey of the tones which the course may take, the next step for those who have the arrangement of the course in charge is to make an analysis of the needs of the students in question, mapping out as accurately as possible the various purposes for which these students are required to take elementary chemistry.

Analysis of the Students' Needs.

The most ardent exponent of the "job-analysis" idea is Dean Charters of the Carnegie Institute of Technology. Following Dean Charters plan (in so far as we were able with the facilities at hand), a committee of elementary chemistry teachers from our department undertook some time ago to determine the purposes for which students of schools and departments other than our own (Natural Science) were taking our first year course. Our ultimate aim was to secure some tangible data upon which we could base a decision as to what type of course we really should give to students of these various groups. The following outline gives an abbreviated form of the general summary which we made:

Student's Department.	*Purpose for which the student is sent to us.*
Liberal Arts.	(1) To aid in the interpretation and appreciation of various common phenomenon.
General Agriculture. (This group includes all students of the School of Agriculture except those in the department of Chemical Agriculture.)	(1) Same as Liberal Arts, purpose (1). (2) To act as a preparatory course for future chemistry courses, such as, General Agricultural Chemistry (required of entire group) and various other pre-vocational chemistry courses, such as dairy chemistry for students of Dairy Husbandry, etc. (3) To act as a preparatory course for future vocational courses, such as, *soils*, a course for agronomists, etc. (4) To act as a preparatory course for the students' future vocational career.
General Engineering. (This group includes all students of the School of Engineering except those in the department of Electrochemical Engineering.)	(1) Same as Liberal Arts, purpose (1). (2) To act as a preparatory course for future chemistry courses. (Applicable to a few cases only.) (3) To act as a preparatory course for future vocational courses. (4) Same as Agriculture, purpose (4).
Home Economics.	(1) Same as Liberal Arts, purpose (1). (2) To act as a preparatory course for future

chemistry courses, such as elementary Organic Chemistry, Household Chemistry and Food Chemistry.

(3) To act as a preparatory course for future vocational courses, such as, housewifery, industrial art, cooking, etc.
(4) Same as Agriculture, purpose (4).

Mining.

(1) Same as Liberal Arts, purpose (1).
(2) To act as a preparatory course for future chemistry courses, such as quantitative analysis, physical chemistry, and metallurgical analysis.
(3) To act as a preparatory course for future vocational courses pertaining to metallurgy and mineralogy.
(4) Same as Agriculture, purpose (4).

With the above analysis of the student situation before us, we then searched through the college catalogue and listed in card-index form all courses upon which the science of chemistry might have any bearing, either directly or remotely. We then interviewed the instructors of these courses personally, studied the contents of the textbooks which they used, and gathered together all the points of contact between our subject and their own. In order to get a number of points of view concerning what our elementary chemistry training was expected to do for the students of the various schools, we likewise sought out the opinions of representative men of the various schools.

CONCLUSIONS DRAWN IN THE PARTICULAR CASE IN QUESTION.

In presenting this data I have no thought of attempting to force our own specific conclusions upon any other college or university. Conditions vary; facilities for presenting the subject are not uniform. The main purpose of this paper is to recommend that some form of analysis similar to the one outlined briefly above be undertaken in all schools which deal with a large number of elementary chemistry students who are not taking chemistry as a major subject. When the analysis of the conditions as presented by one individual school is made, this school will then be obliged to work out its own specific problem in its own way.

As a matter of general interest, however, I will give you a general outline of the conclusions which we have drawn from our own case:

(1) Purpose (1) should be of primary interest in the treatment of all classes of students for whom the analysis was made.
(2) Purpose (4) is, in every case, adequately covered by other courses which the student takes before leaving college.

(3) Purposes (2) and (3)can best be served by the use of a course based on sound fundamental principles, vitalized, however, by a wise choice of general illustrative material, with a possible vocational slant to this illustrative material toward the latter part of the course.

ELEMENTARY CHEMISTRY AS A CULTURAL SUBJECT.

Even if we should agree that the primary aim in teaching elementary chemistry to non-chemists is to aid in the interpretation of problems common to the experience of all, we would in all probability fail to agree as to the best method of accomplishing this purpose. In the case of our own department, we believe that course (3) as outlined above is the most satisfactory method of presenting this type of course, although we admit that the success of this type of course is dependent almost entirely upon the individual instructor in charge of the course. We are not in sympathy with the so-called popular or informational course for the students of the Liberal Arts. We admit that students of this type want chemistry as a means of gaining an insight into and an interpretation of the things of common experience, but we do not believe that this end can be accomplished by making a fetish of an exact science. The student wants power to apply a few fundamental, underlying truths to an infinite number of practical experiences. This power is not gained, in our opinion, by entertaining the student with a hodge-podge smattering of superficialities.

DOES A STRICTLY VOCATIONAL COURSE IN ELEMENTARY CHEMISTRY HAVE A PLACE IN THE COLLEGE COURSE?

We do not believe that an elementary chemistry course should be made to have a strictly vocational purpose. To give to students as their first work in college chemistry a course as outlined under possibility (2) above is to place the course distinctly in the trade-school type of elementary chemistry presentation. This results in limiting the student's vision by attention on a very narrow portion of a broad general subject. The making of elementary chemistry strictly vocational has another tendency, we believe, which is even more serious: It caters to an already too deeply rooted tendency on the part of modern education, in general, namely, it encourages the student to interest himself solely in those things which make an immediate appeal to him as being definitely related to the job by which he intends to make a livelihood. The student who looks at every subject from this angle and from this angle alone is prostituting his college work to a preparation for mere professional success and material gain. Students who look

upon elementary chemistry solely as a means of preparing themselves for the more technical side of a vocational profession are, in the words of Professor Vernon of Carleton College, comparable to persons who study English merely to aid them in writing better business letters.

Having presented our reasons for opposing a strictly vocational course as the first chemistry which a student receives in college, we are now forced to admit that we ourselves as chemistry teachers are largely responsible for the recent demands from many educators for this type of course. Our own inclinations toward the ultra-conservative have in many cases divorced our science from things vital, to the extent that the reaction in the other direction has come as a logical result. It is time that teachers of the extremely conservative type exchange ideas with those of the ultra-radical tendencies, in order that some sort of satisfactory middle course be explored.

Place of the Vocational Course in the College Curriculum.

We have given you above our reasons for not favoring a strictly vocational course in the first year of college chemistry. We do believe, however, that the vocational chemistry course has a distinct place in the curriculum for students enrolled in the various vocational departments of the college. We ourselves are unwilling to turn our chemists out into the world to work out their own salvations with merely the training which they have received in the purely theoretical courses in chemistry. We see no reason, therefore, for refusing to extend the opportunity of receiving the same sort of preparation to students of other vocational departments. As to the place of college vocational chemistry courses, however, we believe that they should follow, and not take the place of the first year course of general elementary chemistry. We believe that vocational chemistry courses of this nature should be taught by chemists rather than by members of the vocational departments in question, but we realize that in addition to being a chemist, a teacher of a special course in applied chemistry should be willing to go any lengths in order to get the point of view of the department for which the particular course is designed.

CONCLUSION:

(1) Regardless of the conclusions reached, we advocate that all chemistry departments who teach elementary chemistry to students of a wide variety of interests make a careful analysis of the needs of the students in question.

(2) We do not believe that the elementary chemistry course should be strictly "informational" or "pre-vocational" in character. We do acknowledge, however, the passive, formal treatment characteristic of many chemistry teachers is equally wrong, and we therefore recommend that a middle course between these two extremes be pursued.

(3) In order best to serve the needs of students enrolled in vocational departments, we recommend that the chemistry teacher ask the cooperation of members of the vocational department in order to get the point of view of the department from which the student comes, and in order thus to serve his needs better.

THE SHALE OIL INDUSTRY IN AMERICA.

BY ARTHUR J. FRANKS,

Colorado School of Mines, Golden, Colorado.

When we speak of an American shale oil industry we have in mind a picture of the future rather than the reality of the present. Much has been written concerning the brilliant possibilities that lie in our deposits of oil shale; and considerable difference of opinion has arisen among a number of so-called "authorities" as to just how brilliant this future actually is. Regardless of all controversy, there can be no doubt that a great shale oil industry will, and eventually must develop, if our present mode of living is to continue. There must sometime come an end to our supply of petroleum. Shale oil, the nearest relative of petroleum, will then be our chief recourse.

This much is generally conceded. The main question upon which there is so much disagreement may be stated in one word, "When?" I do not propose to answer this question. In fact, a satisfactory answer is hardly possible at the present time. I shall merely present a brief outline of the basic operations in the manufacture of the important products of oil shale, and point out the economic factors which must be considered if one desires a clear picture of the future. The reader may decide for himself what really may be expected of this infant industry.

The shale oil industry originated in France during the early part of the nineteenth century. It has reached its largest growth in Scotland, where the production of shale oil and its products has been on a commercial basis for about seventy years. Within the past two decades the industry has paid large dividends in spite of the ever increasing production of petroleum.

The Scottish shale differs greatly from most American shales. Industrial and economic conditions are also unlike those in the United States. Therefore, the industry cannot be transplanted *per se* and *in toto* into this country. This fact has been proved recently in Colorado.

Oil shale is widely distributed in the Western Hemisphere. In the United States the richest and at present the most important deposits are in northwestern Colorado. The origin of these shales is still uncertain. The general opinion is, however, that the material in the shale which yields the oil is of vegetable rather than animal origin. When this material is destructively distilled, oil is evolved. No oil, as such, is found in the original shale.

Colorado oil shale is found in seams of varying thickness. The richest and most workable strata are located at an elevation of about 7500 feet and lie between other strata of lesser or no value. Therefore, the shale must be mined. The methods which appear to be most satisfactory are modifications of those now used in coal mining.

The shale is sent from the mine to large crushers where it is reduced to a size which is adaptable to the particular retort which is to be used in making the oil. Since a rich shale is very tenacious, it is difficult to crush, and only certain types of rotary crushers give satisfactory capacity.

The shale passes from the crushers to the retorts where it is heated to a temperature which generally does not exceed 450° C., until oil vapors are no longer evolved. The gases and vapors are led from the retort to the condensers where the latter are changed to the liquid state. The products of retorting are: crude shale oil, ammonia, water, "fixed" gas, and spent shale. The last product is usually worthless.

The crude oil is now refined by methods similar to those used in the petroleum industry. This involves separation of the various fractions by distillation. Chemical treatment of the distillates is required in order to make marketable products. The products most easily prepared are: Gasoline of a superior

quality, kerosene, fuel and flotation oils. Lubricants may also be made but the refining losses are generally quite high. The ammonia is usually converted into ammonium sulfate which has a small market value. The fixed gas is most advantageously utilized as a fuel for distilling the shale. With an efficient retort sufficient gas is formed to carbonize the shale completely.

Since satisfactory products may be made from shale oil, one may well wonder why there is no plant in America producing shale oil products commercially. The main reasons are economic rather than technical, and involve the same factors which will operate to obstruct the growth of the industry in the near future. These may be summarized under three heads:

1. High initial cost of equipment because of the numerous operations which must be conducted on a large scale, in order to yield a satisfactory profit.

2. High cost of mining as compared to the present value of the products.

3. Heavy losses which are sustained in refining some of the products, and also higher refining costs, as compared to those for petroleum.

The results of recent researches indicate that some of the refining problems are practically solved. But much more work must be done. The industry will lean heavily on the chemist and engineer, as well as the financier if it is to bring about the realization of the hopes and predictions of its sponsors. If a few technical obstructions can be removed, along with the unreasonable prejudice that has arisen in certain quarters, I have little doubt that this potential industry will become a reality of stupendous import.

THE SEARCH FOR OIL IN OKLAHOMA.

The oil men of the United States have become acquainted with the work of the United States Geological Survey in Osage County, Okla., through the advance chapters of Bulletin 686, each describing the geology of one or more townships in that county. These chapters were issued from time to time as they were prepared, and the editions of most of them are exhausted, but the complete volume has now been published.

This bulletin describes briefly the rocks in Osage County, furnishing only such information as may help geologists to trace the formations upon which the determinations of geologic structure are based. It includes brief descriptions of the character of the surface, the drainage and other features. Particular attention is given to the structure as it is indicated by the rocks that crop out at the surface, though the relation of the structure of the surface beds to that of the deep-lying oil sands is also shown, for one or two small areas. The bulletin contains many structure maps which show the development of the oil fields at the time the field work was completed.

DISCUSSION OF "ORAL VERSUS WRITTEN INSTRUCTION AND DEMONSTRATION VERSUS INDIVIDUAL WORK IN HIGH SCHOOL SCIENCE" (COOPRIDER).

By H. M. Morley,

Polytechnic High School, Los Angeles, California.

The study presented in the December 1922 issue under the above title is commendable in many ways. The problem of increasing the efficiency of teaching high school science has been attacked in an open-minded and scientific manner. It shows much painstaking labor and careful thought. Above all it shows the spirit of finding out by trying instead of by talking. Any difference I may have with the conclusions drawn by the author should not be construed as an attempt to belittle his work or to question the data presented, but merely a question of judgment as to the interpretation to be given.

First let me summarize the work of his paper: A laboratory class in sophomore high school biology was divided into sections and the experiments handled in four distinct ways, namely, demonstration by the teacher after giving instructions orally, demonstration by the teacher after the pupils had read printed instructions, individual work after oral instructions, individual work with printed instructions. After the performance of the exercise by the teacher or the individual pupils as the case might be, each student wrote a report on the exercises under the headings of "Object", "Procedure," "Results," and "Conclusion." On this basis, the class averages on twelve experiments were as follows:

Demonstration with oral	74.4%	With written	69.6%
Individual with oral	75.8%	With written	67.7%
Oral for demonstration	76.2%	For individual	76.6%
Written for demonstration	68.9%	For individual	65.0%

Five conclusions are drawn by the author and in connection with them I offer certain comments.

"(1) Exercises with oral instructions give better results than exercises with written instructions in both demonstration and individual work." This follows from the percentages in every case and is what would be expected, as it is well recognized that pupils in general have more difficulty in getting the meaning from a printed page than when told by word of mouth.

"(2) Individual work with oral instructions is more efficient than demonstration work with oral instructions." This also follows from the figures and again is what we would expect, because it seems natural that a pupil will understand better

what he has done with his own hands, than he will something that his teacher performs before him; in other words, his visual perceptions are reinforced by his touch perceptions.

"(3) Demonstration work with written instructions is more efficient than individual work with written instructions." This follows from the figures but the result could hardly have been foretold. Evidently the disadvantage of getting a meaning out of a printed page is more serious than the lack of reinforcing the visual perception, because it appears that the explanation given to the print by the demonstration brings more understanding than is gained by personal manipulation.

"(4) Demonstration work is better than individual work." The figures slightly favor the contrary, and to make the author's reasoning clear I will quote from his paper. "The amount of time consumed by the classes working the exercises by the individual method was about twice that required by the demonstration method. This would be a decided advantage for the demonstration method. If the results of the demonstration work and the individual work are nearly the same, then, it seems that the demonstration work would not only be a time-saving device but also a great saving in the purchase of extra laboratory equipment necessary for individual work."

"(5) Our present methods of science instruction fall short in teaching the pupil to reason scientifically." We may accept this without comment.

The correctness of this fourth conclusion is the heart of the whole matter. Is the demonstration method better? What is the object of a laboratory course in biology? Is it to memorize statements, learn about procedures, observe results, reason to conclusions, and write a report? Yes, and more. It should give the student practice in setting up and handling apparatus, and have him acquire some degree of manipulative skill; this is especially important if it happens that biology is the only laboratory science taken in his high school course.

Another feature to be considered is the thrill that a pupil gets in personally unraveling the mysteries of nature, and the appreciation that he gets in reinforcing his sight by his other senses, the feeling, sound, taste, or smell, of the operation performed. These two features of the course have been neglected in compiling the relative percentages, but should be given proper weight. It would be difficult to quantitatively measure the second one, but the first one could be measured by a proper test

as the government did for trades during the war. For instance, having each pupil set up a microscope and focus it on a given solution, as vinegar, and sketch what is observed, would test much that is not included in the mark given on the report previously described.

If due allowance was made for the laboratory technique acquired, it seems likely that the percentages would still further favor the individual method. It is another question whether or not they would outweigh the advantages cited for the demonstration method, viz., less apparatus and less time spent. Another thing that must be borne in mind is that too much dependence must not be put on the results of such a small number of experiments as twelve.

Everything in this world is a compromise, and it is probable that the best method is one that combines a certain amount of demonstration work and a certain amount of individual work, some experiments being done one way and others the other way. Learning to do is a long slow process, but the pupil of today must learn to do as we learned to do a generation ago, by doing.

CORRELATION OF TEST-SCORES IN CHEMISTRY AND HANDWRITING.

By Stephen G. Rich,

New York University, New York, N. Y.

In June 1922 the writer used the Bell-Texas Chemistry Test on two classes in chemistry taught by him at the Concord State Normal School, Athens, W. Va. One class consisted of beginners in chemistry, 14 in number. The other class consisted of students who had had a year of chemistry in high-school; these were six in number. In making up the term-marks for the classes, the Bell-Texas results counted one-third, the writer's examination on the subject-matter covered one-third, and the laboratory work as indicated by careful supervision of the last two or three experiments in the term done by each student, one-third. It may be added that for the beginners the Second Semester Cooperative Tests devised by the teachers of Cleveland, Ohio, was the basis of the writer's examination.

At the suggestion of Dr. James E. Lough of New York University the handwritings of the students were scored from the Bell-Texas test papers, which have been preserved by the writer. The Ayres Three-Slant Scale was used. Coefficients of correlation, using the Pearson rank-formula were then computed.

In explanation of the rather high figures for the term-marks

in chemistry it should be noted that the passing-mark in that school is 75, and that the bulk of the marks are usually distributed between 80 and 87.

The students ranged in age from 18 to 25 years; all save one in each group were boys.

For the purposes of this study the two classes were lumped together as one group, and the results computed on this basis.

The scores for the various methods of rating are:

(1) Bell-Texas Chemistry Test.
Highest 86, lowest 40, mean 66.0

(2) Term-mark in chemistry.
Highest 95, lowest 60, mean 81.7

(3) Ayres score in handwriting.
Highest 80, lowest 40, mean 64.0

The coefficients of correlation, calculated as indicated above, are:

(A). Bell-Texas and Ayres: $r = .365 \pm .11$
(B). Term-mark and Ayres: $r = .41 \pm .13$
(C). Term-mark and Bell-Texas. $r = .43 \pm .12$.

The large part played by the term-examination and especially the laboratory work in making up the term-mark will explain the low correlation between the latter and the Bell-Texas score.

The correlations (A) and (B) indicate that the habit-formation involved in writing is quite distinct from the ability to remember chemical information and from the habits involved in successful learning to do laboratory work in chemistry. This latter result is somewhat out of accordance with the doctrine of a general type of habit-formation underlying all processes of this sort; such a doctrine is held by a number of educational psychologists.

NATIONAL SECURITY LEAGUE ACTS TO PROTECT TEACHER SALARIES.

In line with its policy of safeguarding the interests of teachers and schools Mr. S. Stanwood Menken, founder and President of The National Security League, sent the following telegram to the Department of Superintendents meeting at Cleveland to be read at the session on Tuesday morning, February 27th, when the Superintendents were to discuss the subject of school financing:

"The National Security League congratulates your Department on today's session on a subject so fundamental to the welfare of public education. The League stands squarely for higher educational standards and attracting the finest ability to the teaching profession by adequate salaries. There must be no retrenchment in school expenses which would injuriously affect teachers' salaries which, in many places, are yet so low as to interfere seriously with school efficiency. Public edueation being the greatest single factor in national security we extend our best wishes for the success of your endeavors."

The League, a few years ago, initiated a nation-wide movement for better salaries for teachers and better school conditions generally and was successful in arousing public interest in many states which resulted in a general upward revision of teachers' salaries.

LABORATORY METHODS IN HIGH SCHOOL SCIENCE.

By J. L. Cooprider,
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Introduction.

In the December, 1922, number of School Science and Mathematics, (Vol. XXII, pp. 838-844) I presented some research on laboratory methods in high school science. At the suggestion of Drs. Charles H. Judd and Elliot R. Downing of the University of Chicago and a few others I continued the work referred to above with the idea to attempt to discover the relative retention value of four methods of presenting laboratory exercises in high school science. I wish to state that I do not wish to present a study that is new and that has not been discussed before, but rather I should like to present a study giving some new statistics relative to our present methods of science instruction.

Methods.

The data for this study were secured by giving twelve typical laboratory exercises to sixty-eight students of sophomore grade in a general course of high school biology. These students were divided into four sections of about the same number of students to each section, the native ability of each section being about the same. Four methods were used to present each exercise, viz., demonstration with oral instruction, demonstration with written instruction, individual work with oral instruction and individual work with written instruction. Each of the four sections worked each of the twelve exercises by a different method. The methods were alternated so that each class performed three exercises by each method. In the demonstration work the exercise was presented by the instructor and in the individual work the exercise was performed by the students. If the instructions for working the exercise were oral, the instructor read the instructions, but if they were written the instructions in type-written form were given each student. Both the oral and the written instructions were given before the exercises were performed. No discussion was permitted other than the reading of the instructions; neither did the student retain the type-written instructions after the exercises were begun. No discussion was permitted while the exercises were being performed and written; neither was there any discussion that related to the exercises after the exercises were written until the test was made one month later.

In making a record of each exercise, each student filled out

incompleted sentences, which were given him after the exercise was performed. One month after the exercises had been performed these same incompleted sentence forms were given each student and he was asked to fill out the blanks as nearly the way he had originally as he could. Both the original records and the records made one month later were scored on the same basis. The students' record consisted of four divisions: object, procedure, results and conclusion. The "object" was a statement of the purpose of the exercise; the "procedure" was a record of the things that were done in working the exercise; the "results" was a record of the observations made by the student; and, the "conclusion" was a summary of the things to be proven, tested, or learned. A total score for each student was determined by dividing the sum of his per cents by four. It is the average of these total scores that are presented below.

THE RESULTS OF THE STUDY.

The results of this study will be taken up under three headings: (1). The original scores; (2). The scores made one month after the exercises were performed; and, (3). A comparison of the original scores to the scores made one month later.

(1). THE ORIGINAL SCORES. In the table given below it may be noted that the total average (for twelve exercises) in the demonstration work with oral instructions is 64.17 per cent; for the demonstration work with written instructions it is 63.55 per cent; for the individual work with oral instructions it is 65.16 per cent; and, for the individual work with written instructions it is 60.24 per cent.

The average for the demonstration work with oral instructions is (64.17—63.55) 0.62 per cent higher than the average for the demonstration work with written instructions, and, the average for the individual work with oral instructions is (65.16—60.24) 4.92 per cent higher than the average for the individual work with written instructions. This means that the averages with oral instruction are higher than the averages with written instruction.

The average for the demonstration work with oral instructions is (65.16—64.17) 0.99 per cent higher than the average for the individual work with oral instructions, and the demonstration work with written instructions is (63.55—60.24) 3.31 per cent higher than the average for the individual work with written instructions. This shows that the average for the demonstration work is higher than the average for the individual work.

SUMMARY: To summarize the above averages as based

upon the original scores it can probably be stated that: (A). Oral instructions give better results than written instructions; and, (B). demonstration work seems to be more effective than individual work.

(2). THE SCORES MADE ONE MONTH LATER. The table on page 529 shows that one month after the work was done the students made an average score in the demonstration work with oral instructions of 35.82 per cent; for the demonstration work with written instructions it is 33.65 per cent; for the individual work with oral instructions it is 32.71 per cent; and, for the individual work with written instructions it is 37.47 per cent.

In the demonstration work the average with oral instructions is (35.82—33.65) 2.17 per cent higher than the average with written instructions, and in the individual work the average with oral instructions is (37.47—32.71) 4.76 per cent less than the average with written instructions. This would indicate that the demonstration work gives better results if the instructions are oral and that the individual work gives better results if the instructions are in written form.

The average for the demonstration work with oral instructions is (35.82—32.71) 3.11 per cent higher than the average for the individual work with oral instructions, and the average for the demonstration work with written instructions is (37.47—33.65) 3.82 per cent less than the average in the individual work with written instructions. It seems here than the demonstration work is better than the individual work where the instructions have been oral, and that the individual work is better than the demonstration work where the instructions have been written.

SUMMARY: To summarize the above averages as based upon scores made one month after the exercises were performed, it can probably be stated that: (1). Demonstration work with oral instructions is more efficient than demonstration work with written instructions. (2). individual work with written instruction is more efficient than individual work with oral instructions. (3). There is not much difference between work done by demonstration and individually.

(3). A COMPARISON OF THE ORIGINAL SCORES TO THE SCORES MADE ONE MONTH LATER. In making this comparison it was assumed that the original scores represented 100 per cent of the students' efficiency. In the table given, herein, the per cent score made one month after the

exercises were performed was divided by the original per cent score in order to determine the per cent of the original scores that were retained after one month. After this calculation, we find that the average score for the demonstration work with oral instruction is 55.82 per cent; for the demonstration work with written instruction it is 52.95 per cent; for the individual work with oral instructions it is 50.19 per cent; and, for the individual work with written instructions it is 62.20 per cent.

TABLE 1. Showing the total average scores of twelve laboratory exercises performed by 68 high school students in biology.

Methods of presentation	Original score in %	Score one month later in %	% the score one month later is of the original score
Dem. with oral instruction	64.17	35.82	55.82
Dem. with writ. instr.	63.55	33.65	52.95
Indiv. with oral instr.	65.16	32.71	50.19
Indiv. with writ. instr.	60.24	37.47	62.20

The scores representing the amount retained after one month show that the demonstration work with oral instruction is (55.82—52.95) 2.87 per cent higher than the demonstration work with written instruction, and, that the average for the individual work with oral instructions is (62.20—50.19) 12.01 per cent less than the average for the individual work with written instructions. From this it seems that instructions for demonstration work should be oral and that the instructions for individual work should be written.

In the exercises where the instruction was oral, the averages in the demonstration work seem to be (55.82—50.19) 5.63 per cent better than the averages in the individual work, and, where the instruction was written, the averages for the individual work seem to be (62.20—52.95) 9.25 per cent better than the averages for the demonstration work. The difference between 9.25 per cent and 5.63 per cent or 3.62 per cent would thus be in favor of the individual work.

SUMMARY: In summarizing this division of the study it seems that: (1). Demonstration work should be given with

oral instruction. (2). Individual work should be given with written instruction. (3). Individual work should be given in preference to demonstration work.

GENERAL CONCLUSIONS.

If our purpose in laboratory exercises is to meet immediate needs, it would seem that oral instruction should be given in preference to written instruction. This would eliminate the class use of laboratory manuals in high school science. Also, demonstration work should be given in preference to individual work. This would eliminate the amount of time required to do individual work, since more work can be done in the same amount of time by the demonstration method. The demonstration would also eliminate the added expense necessary to equip and supply laboratories in order to do individual work.

On the other hand, if we wish our students to retain laboratory work, it appears from this study that demonstration work should, be given with oral instructions and the individual work with written instructions. Also, individual work should be given in preference to the demonstration.

THE SLIDE RULE IN TEACHING CHEMISTRY.

BY S. G. RICH,
New York University, New York City.

During the academic year 1921-22 the slide-rule was introduced into the work of the Concord State Normal, Athens, W. Va., where the writer then taught, as an incident to the beginning course in physics. Several of the students were also taking courses in chemistry; this gave opportunity for a study of the availability of this instrument in chemical calculations.

We found in the ordinary stoichiometric problems and in problems involving calculations by Boyle's Law, Charles' Law, the two together, or the gram-molecular volume, that the students using the slide-rule saved roughly two-thirds of the time taken by those attaining equally good marks on the problem work but doing it by ordinary arithmetic. Two students used logarithmic tables for a time, but with only half the time-saving gained by the users of the slide-rule.

In the matter of accuracy, we found that the slide-rule workers were, within the limits set by the slide-rule itself, somewhat more accurate than those doing the work by arithmetic. This I attribute to the fact that each of the operations or settings with the slide-rule can be given full time and attention for accuracy without delaying appreciably the obtaining of the answer.

The matter of accuracy has another phase, in which the slide-rule scores heavily. As a general thing, students in the first and even the second year of chemistry are not able to guarantee their weighings and measurements of volumes to more than three significant figures. The slide-rule, working to three significant figures, avoids the common fault of giving calculated results that show a higher degree of accuracy than the data warrant. It is notorious that students are, as a rule, not able to remember that they must give results of the same degree of accuracy—*and of no greater degree*—than their data; and it is likewise well known that very few students are able to save their time by the use of approximations in calculation. The use of the slide-rule eliminates these two causes of difficulty.

We were sufficiently satisfied as to the advantages of the slide-rule for chemistry instruction to have adopted for the year 1922-23 a regulation that every student who took second year work in chemistry would be required to use the slide-rule. It was my intention to put strong pressure on the first year students of the subject to get and use a slide-rule; I expected to give instruction in its use at the beginning of the school year. The cost of slide-rules is not excessive; but we hoped to reduce it still more by using the new circular slide-rule at $1.50, put out by a firm in Michigan.

THE CANDELARIA SILVER DISTRICT, NEVADA.

Candelaria, an old silver-mining camp in western Nevada, has produced $20,000,000, mainly during the seventies and eighties of the last century. The ore worked in those early days averaged $40, $50, or more a ton, but such ore has long been exhausted, and the attempt now being made to revive the camp is based on the belief that there is still in the ground considerable ore of moderate grade—ore carrying 10 to 15 ounces of silver to the ton—from which a profit may be won by modern methods of mining and metallurgy. A brief report issued by the United States Geological Survey, Department of the Interior, indicates that the future prosperity of Candelaria is not to be sought by exploring to greater depth but must be won by working ground that lies above the deepest levels already worked. The progress made in metallurgy has solved the problem of reducing economically the rebellious silver ore of Candelaria, but the efficient mining of the ore—its discovery and extraction at a lower cost than was possible in bonanza days—is a matter in which the passage of time has not so unreservedly favored the present generation. To achieve success in reviving Candelaria will especially require engineering and administrative skill of the first order.

The report sketches the history of the camp, gives an outline of the geology of the religion and describes the character of the ores and the features revealed at the mines.

ON THE TEACHING OF HIGH SCHOOL CHEMISTRY

By W. C. Hawthorne,

Crane Junior College, Chicago, Ill.

I cannot resist the temptation to enter a vigorous protest against some inferences that might be drawn from the article in the March number of School Science and Mathematics, entitled "How to Get a Closer Relation Between the Chemistry of the High School and the College: From the Standpoint of the College."

The urge thereto is greater because of the number of excellent things in the article. We would all agree, for instance, that the high school course in chemistry does not exist merely for those who are expecting to go to college. We would all agree on the importance of a knowledge of chemistry to the educated man. Nor would we take exception to the statement that high school chemistry should be mainly informative, although that it should contain nothing but information is more than doubtful. Professor Reedy's ostensibly advocated aims are, I believe, those of every high school instructor in chemistry. It is when he begins to particularize as to methods and details that the opportunities for misunderstanding crop out. Apparently, we must take issue with him on some of these. For instance, it is impossible for me to see how a modicum of chemistry that is to be of any value can be taught without reference to the basic laws of the subject.

To begin with, he would have the kinetic and atomic theories omitted. What else, permit me to ask, makes our work in the laboratory of any more educative value to the student than that performed in the kitchen? What else will give him any understanding of the underlying structure of, and the ceaseless forces at play in, the materials which he is forcing into new combinations?

"Omit the Periodic Law:"

Has any more magnificent device for aiding us to remember the properties and relationships of the elements ever been devised in the whole history of chemistry than this same Periodic Law? To omit this will be to increase enormously the difficulty of retaining the very *facts* that Professor Reedy insists should be learned.

Probably we would all agree upon the value of "giving the student as much usable information as possible." But who is to know what information is to be most usable in ten, twelve, or fifteen years after the student has left your class? The principle

of a scientific law thoroughly learned and illustrated by as many practical applications as possible will always be valuable. But "Why Missouri zinc ore is smelted in Danville, Ill." may or may not be valuable. "Explain why iron ore is mined in the Upper Peninsulas but smelted in South Chicago." And also, I suppose, "Why the Chicago consumer has to pay Pittsburgh plus."

Professor Reedy seems to think that such subjects as radioactivity and atomic disintegration should be kept from the student's attention. I am reminded of the post-war doggerel, "How you goin' to keep them down on the farm, after they've seen"—the papers and magazines full of these topics? Some high school students, unlike many college students, have inquiring minds; they want to know, and they should be encouraged to know, to branch out in as many different directions as possible. When they come to the teacher for an explanation of something they have read in "Popular Science," (often more popular than scientific, I admit) shall they be told, "Don't try to understand this until you get to Chem 17b or 22x in college. Learn this reaction between hot HCl and MnO''_2? Do this about twice and you have killed their interest in you as a teacher, if not in chemistry.

Whether or not it is a mistake to begin with the study of oxygen depends on how the subject is treated. If our method of approach be through the familiar processes of oxidation, certainly we cannot go far wrong. An understanding of oxidation and reduction is certainly fundamental to any organized conception of chemistry. So, too, with the ionization hypothesis and the notion of reversible reactions. How else can the student classify his knowledge regarding acids, bases, precipitates, etc., so well or so easily as by getting an appreciation of these laws? Not, of course, such an appreciation as the college student *ought to have*, but such an appreciation as shall enable him to see that the action of hydrochloric acid on silver nitrate solution and on baking soda belong to the same category.

Let me say here that a long acquaintance with college students from both sides of the teacher's desk has convinced me that there is generally a big difference between the teacher's "ought to have" and the student's "does have." Between the capacity of the high school senior and that of the college freshman there is no great gulf. I have taught chemistry to both, and I know that many of the former class knew more of the subject at the end of the year than some of the college men had absorbed during their year of wrestling with the subject.

I shall protest, furthermore, against holding the high school teacher responsible for every blunder made by college students. Every teacher knows how slippery are mere facts, how easily forgotten, how sadly tangled after a few years. Had the physician who wrote HCl and $Mg(OH_2)$ in the same prescription never attended college? Had he never heard anything about incompatibles in his medical course? I, too, can tell of the physician who sat across the table from me in the dining car and admitted that he had studied chemistry when he *went to college*, but "never having found any use for it, had forgotten about everything except that *water is* H_2O."

No one knows better than the experienced teacher of chemistry that there are faults in the pedagogy of the subject. Few there are who are not willing to learn; but they must learn in the class room. Although the young teacher "usually tries to teach just as he was taught in college," he generally improves on the technique of his college instructor after a few years.

But let us not forget to notice some of the good points in the article. Professor Reedy hits the nail on the head in his last paragraph, "Train them for living in sympathetic relationship to modern life." Much the same thought underlies another aphorism, "While the college teacher must teach the subject, the high school teacher must teach the pupil." If he believes this, it is difficult to see why he objects to popular lectures on scientific subjects, educational movies, and excursions to industrial plants. From the standpoint of the teacher of college chemistry, they may have little or no value: from the standpoint of the teacher of the child, as a means of getting him into "sympathetic relationship to modern life," they may have much.

We shall all heartily applaud the following statement: "If we can only bring our boys and girls to understand the everyday applications of chemistry, they will have no trouble about entrance credits. The problem is merely to establish a new point of view." Again, that sentence, "A high school chemistry course that does not make the boys and girls work—yes, and make some of them fail—is not worth much" ought to be in letters of gold above every teacher's desk. But how such a course as he seems to suggest is going to demand any "constructive thinking," or anything but mere memory work, one cannot see. When the fundamental laws by which we are enabled to "classify knowledge" have been omitted, we have not Science but Nature Study.

I am reminded of an incident that occurred in a conference a number of years ago when a gray-haired, experienced teacher of chemistry, whose pupils were always welcomed at the university, was in the chair. An enthusiastic advocate of "practical chemistry" had just finished a description of the way he taught it. He was particularly enthusiastic about the interest the boys took in "testing" this, that, and the other thing, and how easy it was to teach the subject if the theory was omitted. At the conclusion of the address, Professor Wirick remarked that he had no doubt such a course was interesting; but not nearly as interesting as a good course in chemistry.

QUICKSILVER OUTPUT STILL LOW.

Preliminary figures showing the production of quicksilver in the United States in 1922, compiled by F. L. Ransome, of the United States Geological Survey, Department of the Interior, give a total of 6,497 flasks, of 75 pounds net, as compared with 6,339 flasks in 1921, which was the smallest annual output in the 72 years of recorded production of domestic quicksilver. In 1922 California produced 3,494 flasks, Texas 2,725 flasks, and Nevada and Oregon 278 flasks.

In California 4 mines were productive, but the output from all but the New Almaden group was very small. The New Idria mine continued non-productive but the old Redington or Boston mine at Knoxville, Napa County, which has lain idle for many years, yielded some quicksilver and will probably be a larger producer in 1923, as a rotary furnace has been installed. In Texas the Chisos mine, in the Terlingua district, Brewster County, yielded more quicksilver than any other mine in the United States. The Marisal mine, near McKinney Springs, in the same county, was also productive. Prospecting was in progress at the Waldron mine, in the Terlingua district, 95 miles south of Alpine. In Nevada the only production recorded was made from deposits in the Pilot Mountains, east of Mina, in Mineral County. The output from Oregon was practically negligible.

The average price of quicksilver in 1922 per flask of 75 pounds, as calculated from quotations by the Engineering and Mining Journal-Press, was $58.95 for New York and $57.78 for San Francisco. The price declined from $51, New York, and $50, San Francisco, early in January, to $48, New York, and $47.30, San Francisco, in February. From the first of March the rise was fairly steady to $74 ,New York, and $71.30, San Francisco, at the end of the year.

The tariff act of 1922, which went into effect on September 21, placed a duty on imported quicksilver, of 25 cents a pound equivalent to $18.75 a flask. At the end of the year the directors of the great Almaden mine, in Spain, where extensive improvements have been in progress, reduced the price of quicksilver at the mine to the equivalent of about $45 per flask.

No important additions to known resources of domestic quicksilver were made during the year 1922, but the effect of the new import duty will probably be seen in a moderate increase in production in 1923.

THE ROLLING CYLINDER AND THE WORK EQUATION.

By Hiram W. Edwards,

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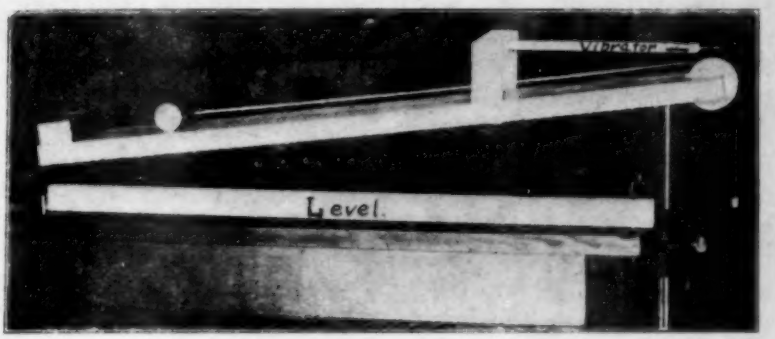
The study of mechanics in college freshman physics is admittedly the most difficult part of the year or two years' course. This may be due to the fact that mechanics is the topic which is usually presented first, or its difficulty may be ascribed to its more mathematical nature. In any case, it is evidently a part of the teacher's duty to provide material which is sufficiently concrete in nature and yet which will permit of as general an application as is necessary to obtain a broad viewpoint of any particular field. In providing illustrative material, care must be exercised so that there be ample opportunity to provoke a reasonable thought stimulating reaction on the part of the student. A laboratory assignment may be of such a nature that a student can fulfill the prescribed requirements without experiencing any of the thought stimulating reactions. Again, the assignment may be so difficult for one of his mental development, that he becomes lost in its complexity and fails to experience any stimulus resulting from a satisfactory and satisfaction giving conclusion. These thoughts were in mind when the apparatus, described below, was designed. It is hoped that there may be in it a real contribution to the study of mechanics and the work equation.

The three fundamental equations of motion in mechanics have been studied in laboratory work in a variety of ways and by many different means. The force equation has been splendidly illustrated with the Atwood's machine. The impulse equation can be verified by the Adams Impulse Balance. A description is given here of a piece of apparatus which has been found useful in presenting the work equation in such a form as to include simultaneously pure translation, pure rotation, and rotation combined with translation.

It will be recalled that the work equation in its general form, in which it applies to uniplanar motion, has for one member an expression involving the sum of all forces, each multiplied by its proper distance factor, and as a measure of this sum the other member of the equation contains the change in energy produced. Either translational or rotational energy or both may be present.

An accompanying cut shows that the essential parts of the apparatus are: an adjustable, inclined plane (about 120cm. long), a heavy brass cylinder (1600 grams, radius 2.5cm.), a pulley

fixed at the upper end of the plane, an accurately timed vibrator (period .121 or .200 seconds) with an inking brush, a strip of paper for obtaining a time record, a small weight (about 70 gs.) suspended by the paper, and finally a long level for obtaining a true level line.



To obtain a set of data the brush is inked and adjusted to make a fine trace on the paper, the vibrator is first released and then the cylinder immediately afterwards. As the cylinder rolls with uniformly accelerated motion down the plane, the inked brush gives a time record on the paper which later may be used for the determination of an initial and final speed at two points selected, for convenience, near the ends of the record. Motion is arrested at the lower end of the plane by a felt pad. Two points may now be selected which are an integral number of time intervals apart, both at points of maximum amplitude, and, of course, in the same phase of vibration. If now the cylinder be rolled back up the plane to positions such that the marked points shall be under the inking brush, the corresponding vertical distances of similarly situated elements of the cylinder above the level baseline may be measured. The vertical fall of the cylinder is thereby obtained. It was found necessary to measure these distances to a tenth of a millimeter. A small square served advantageously here, for by placing it on the lower side of the cylinder, it held the cylinder in place while at the same time projected over the edge of the plane. The vertical distances were measured from the edge of the square to the baseline below. Following these measurements the paper tape could be removed and the necessary measurements made from it for the determination of acceleration and initial and final velocities.

The apparatus has been thoroughly tried out by instructors and students. Results over the range tested have been very

gratifying for in all cases the change in total kinetic energy (including translational energy of the cylinder, its stirrup, paper tape and hanging weight and rotational energy of the cylinder and fixed pulley) has been found to differ from the calculated work by amounts varying from .4% to 1.2%. Taking a mean of these percentages as .8%, one might infer that the energy dissipated in heat was about .8%, for in all cases the energy was found to be less than the work done. The following sample data and calculation were made by a student.

It may be observed that some modifications can be made to extend the usefulness of this aparatus. Two rolling masses might be made having the same mass and moment of inertia but differing in the length of the radius. This would add variety by showing the effect of angular speed upon the disposition of the total energy carried by the cylinder. The apparatus may be used to test the force equation in a manner somewhat similar to that used in manipulation of the Atwood's machine.

Data: SAMPLE DATA AND CALCULATIONS.

Cylinder:

Mass	1600 grams.
Radius	2.54 cm.
Vertical drop of cylinder	8.80 cm.
Initial velocity of cylinder	14.40 cm/sec.
Final velocity of cylinder	82.88 cm/sec.
Initial angular velocity	5.66 rad/sec.
Final angular velocity	32.63 rad/sec.
Moment of Inertia	5160. gm. cm^2.

Pulley:

Initial angular velocity	3.62 rad ÷ sec.
Final angular velocity	20.88 rad sec.
Moment of Inertia	957.5 gm. cm^2.

Hanging Weight:

Mass	69.6 gms.
Vertical lift	77.8 cm.

Stirrup:

Mass	7.6 gms.

Paper Tape:

Mass	125 gms ÷ meter

Calculations:

Translational Kinetic Energy $= \frac{1}{2}(1600+69.6+7.6+1.6) \times (82.88^2 - 14.4^2)$
$= 5{,}592{,}000.$ ergs.

Rotational Kinetic Energy $= \frac{1}{2} \times 5160 \times (32.63^2 - 5.66) + \frac{1}{2} \times 957.5 \times (20.88^2 - 3.62^2)$
$= 2{,}665{,}000.$ ergs.

Total Kinetic Energy $= 8{,}459{,}000.$ *ergs.*

Work done on cylinder, stirrup and paper $= (1600+7.6+.5) \times 980 \times 8.8$
$= 13{,}868{,}000.$ ergs.

Work done in lifting weight and paper $= (69.5+.5) \times 980 \times 77.82.$
$= 5{,}346{,}000.$ ergs.

Total work done by gravity $= 8{,}522{,}000.$ *ergs.*

Excess work done not accounted for by Kinetic energy is .7%.

THE USE OF STANDARDIZED AND PARTLY STANDARDIZED TESTS IN CHEMISTRY AT A NORMAL SCHOOL.

By Stephen G. Rich, M. A.

New York University, New York City.

During the academic year 1921-1922 the writer was instructor in chemistry at the Concord State Normal School, Athens, W. Va. The only courses in the subject that were given were a beginners' course (Chem. 101-102) and a course in general chemistry for those who had previously had high-school chemistry. (Chem. 111-112). The work in both was of college grade; but students who were completing their high-school units that year were allowed to take Chem. 101-102 for high-school credit, getting only the same number of units as for a regular high-school course, although considerably more work was covered. The texts used were Hessler and Smith for 101-102 and McPherson and Henderson's General Chemistry for 111-112. The school year is nine months.

At the time this work was undertaken the only available tests were the Bell-Texas,[1] Rivett's tests,[2] and the Cleveland Cooperative Tests.[3] Inasmuch as Rivett's tests dealt with the subject by sections, they were not convenient for our purposes: the other two were suitable and both were used.

On the day after the Christmas holidays ended the Bell-Texas Test was given to all the pupils in both classes. At the end of the first semester the Cleveland Cooperative First Semester test was given in place of a term-examination in course 101-102.

During the last six weeks of the second semester Rivett's tests were used for review purposes in course 101-102, but no scores kept. At the end of the second semester, just before the final examination period, the Bell-Texas Test was again given to all students in both courses. In course 101-102 the Cleveland Cooperative Second Semester Test was used in place of a term-examination. The test-papers have been preserved, from all four sets, and were recently gone over to detect any possible errors in scoring.

For converting scores into percents for the marking system in use in the school the percentiles corresponding to the various percentages, known for the school's marks as a whole and known within sufficient limits of accuracy for the purpose,

[1]School Science and Mathematics, May, 1918; Journal of Educational Psychology, April, 1918.

[2]School Science and Mathematics, November, 1921.

[3]Journal of Educational Research, November, 1921.

were used. For example, the mark 75 per cent was percentile for fifteen to twenty per cent of the students marked: on the second semester Cleveland Cooperative Test this corresponded to an unweighted score of six questions.

The results were as follows:

1. Bell-Texas Test.
   - 3 months of instruction; 13 pupils.
     - Mean 31.5
     - Median 31.0
     - Q. 5.0
   - 9 months of instruction; 14 pupils.
     - Mean 61.0
     - Median 62.0
     - Q. 14.0
   - 12 months of instruction (1 year in high school and 3 months here): 6 pupils.
     - Mean 60.3
     - Median 59.5
     - Q. 19.5
   - 18 months of instruction (1 year in high school and 1 year here): 6 pupils.
     - Mean 72.3
     - Median 71.5
     - Q. 12.5
2. Cleveland Cooperative Tests.
   - First Semester: 14 pupils.
     - Mean unweighted score: 6.35
     - Mean weighted score: 16.15
   - Second Semester: 14 pupils.
     - Mean unweighted score: 6.35
     - Mean weighted score: 18.1

The norms for these tests are as follows: those with the authors' names are the original ones, and those marked (R) are computed by the writer.

1. Bell-Texas Test.

Number of pupils	Months of chemical instruction	Mean	Median	Q.
50(Bell)	3	51.8(R)	.....	12.5(R)
63(R) including Bell's 50	3	47.5(R)	.....	11.0(R)
350(Bell)	9	59.0(Bell)	.....	9.1(R)
392(R) including Bell's 350 & Gerry's 22	9	58.7(R)	.....	8.1(R)
14(Bell)	12	76.0(Bell)	84(Bell)	7.5(R)
20(R) including Bell's 14	12	71.1(R)	.....	11.1(R)
6(R)	18	72.3(R)	71.5(R)	12.5(R)

2. Cleveland Cooperative Tests.

Number of pupils	Semester	Unweighted Score (Mean)	Weighted Score (Mean)
581(Hayes)	1	9.0(R)	25.05(Hayes)
595(R) including	1	8.75(R)	24.85(R)

Hayes' 581			
268(Hayes)	2	11.2(R)	25.27(Hayes)
282(R) including Hayes' 268	2	10.6(R)	24.9(R)

The norms as given require some interpretation. The following points are relevant:

1. All the norms in which the number of pupils is followed by (R) include the results at Concord in the data from which they were computed.
2. On the Bell-Texas the variability-measure Q is given as being the only one that could be computed from the data that exist as to all schools; Bell's data do not permit of securing A. D. or S. D. As Q approximately = P. E., and as it may be converted to S. D. or A. D. by formula, this is not objectionable.[4]
3. On the Cleveland Cooperative only those data are given that are comparable with the results published.
4. The Bell-Texas norm for three months is probably unduly high, owing to one class of thirty-six pupils that scored very high.
5. The 12-months' and 18-months' norms for the Bell-Texas test are based on too few pupils to have any significance other than as record of what has been attained.
6. The 6 months' norms obtained by Gerry and Briggs[5] are not given above, as there were not any test-results at Concord with which to compare them. For information of those interested, these, combined with the writer's later testing by the Bell-Texas test, they are: 97 pupils; 5 and 6 months of instruction; Mean, 61.0; Q, 7.7.

The correlation between the two tests was computed for the only comparable sets, the 9-months (Course 101-102). By the Pearson rank-formula, $r = .26$; P.E. $= \pm .128$.

Data as to the agreement or lack of it of the work of the Concord students with the scaled values of the Cleveland Cooperative questions and the percents of pupils succeeding on the Bell-Texas test questions were computed; but are hardly relevant here. The Cleveland scale-values are reasonably close to those that would be obtained from Concord results alone; the Bell percentages are fairly close for nine months but widely aberrant for the other times.

Owing to the fact that the tests are not given by the same method, they have unequal value as measures of chemical information. The Cleveland Cooperative questions are read aloud to the pupils: thus the personality of the tester is likely to affect the results. The Bell-Texas test, given on a mimeographed form on which the answers are written, offers more constant conditions. The Cleveland Cooperative tests are limited in being based on one text (not the one used at Concord) and in being standardized on results from only one city.

[4]McCall, W. A., How to Measure in Education. p. 379.
[5]Gerry, H. L., Journal of Educational Psychology, May, 1920; and Briggs, T. H., Journal of Educational Psychology, April, 1920.

Both tests occupy such a short time that all answers are given while the student has not become fatigued; in this they avoid the vitiatation of the measuring-value of those questions on an old-style examination that are answered last. But probably the most important, most significant, and most valuable further advantage that inheres in both tests is that they appeal to the students as pre-eminently fair and just. This particular point, so plainly in opposition with the variability in this respect of the ordinary type of examination, should go far to make the use of modern tests appeal to teachers of chemistry.

It only remains to be said that these tests measure information and nothing else; and that the term-marks were made up by taking the mean, for each student, of the Cleveland Cooperative Score (second semester, course 101-102 Bell-Texas score also used) turned into school grades by percentile method as mentioned above, the quality of the laboratory notes as graded by the instructor, and the instructor's estimate of the work done in a practical laboratory test.

THE SCIENTIFIC ASPECTS OF OUR LANGUAGE.

By Henry Flury,

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In my course in general science, two of the topics which I dealt with among others briefly, were the history of the art of writing and simplified spelling.

These at first sight may seem to belong to the realm of history or of English. They do. But there is a good reason for introducing them in my course. Our general science course is not a preparation for other sciences. It is given to the two-year commercial students—to those who will probably never pursue any other course in science.

The most we can do is to give them a scientific or rational attitude toward life. To explain the events of daily life and to throw out suggestions as to the far-reaching forces that are acting in the universe is our aim.

Now as to language, that is something that is common and is used constantly. It is the medium whereby thought, ideas, are transferred from one mind to another. It also represents an evolution. It has grown up like a garden, but a garden full of weeds along with the flowers. Every other nation but ours and England has attempted to simplify and improve its vehicle of thought transference. A Chinese friend tells me that

even China has recently taken steps in that direction. We, however, have been content to accept the inconsistencies and errors crystallized by the printing press run by Dutchmen[1].

A good book recently published is Mason's "A History of the Art of Writing." It shows how the first and natural reaction of the mind of primitive man led to reproducing or picturing objects, plants and animals about him. Then he began to use those pictures to tell a story—to reproduce a chain of events or an idea. Seeking a vehicle to transfer a thought from the mind of one human to another was truly a noble motive. It was a scientific impulse.

The transition of primitive man from the rough stone to the polished stone marks the advent of the artistic epoch. The transition from the picture to the picture-motion idea marks the inception of the scientific epoch—the beginning of modern progress. Superstition and fear of the wrath of the gods forged the fetters tight on primitive man's slavery to his environment. The knowledge that all events moved by natural law had not yet dawned upon his latent consciousness. But the desire to express his emotions and reactions of his mind led early man to develop a system of oral and recorded language. Culture was thus disseminated.

Pictures took a long time for their drawing and often were hastily and carelessly made. Soon parts were omitted; the ears alone stood for the owl (mulak) (M), the horns for the bull (A) (aleph). Symbols which were thus developed from these partial pictures, the first attempt at "shorthand" gave us our alphabet.

Language is too often taken for granted, like the love of parents, the security of good government, the kiss of your wife and a great many other blessings. Because it is common, its importance is overlooked by those outside the literary field. But the science teacher should show the student that our alphabet and language is not something born fully developed as Athena, but is the result of thought and growth of centuries. Let him see that it has been improved and that it can be improved. Let him adopt a scientific attitude toward language and its improvement as toward all other things human. In this connection I note the simplified spelling of many scientific terms in recent text books. The old oe and ae for example are giving way to e and the final ue is being sent to hibernate with the dodo. The National Education Association, the Depart-

[1]The early printers in England were Hollanders.

ment of Agriculture, countless journals and newspapers are gradually accepting and using the shorter and clearer and more scientific forms.

To offset this hopeful tendency, however, I cannot refrain from being distressed at the looseness of language (if not of thought) of many of our educational writers and scientists. How many, many writers there are who ought to know better who use the word "infinitely" indiscriminately. How often we hear a public speaker use the expression "meet together" or "gather together." In a geometry by Wentworth (an old edition, I believe) I ran across the statement of a theorem as follows: "If two chords intersect *each other* the angle formed is equal to one half the sum of the intercepted arcs."

Loose writing and speech accompanies loose thinking. A man who uses the word "infinitely" loosely cannot be a very deep thinker. A good workman always looks at his tools before and during his work. Words are the tools and language the vehicle by which the scientific worker transfers his ideas. Of all persons, therefore, the scientist should have a firm grasp on the English language.

Noah Webster was the first American to inaugurate the simplification of our spelling and it behooves the science teacher to induce his sutdents to cultivate a more extensive acquaintance with that author and himself undertake a study into the origin, development and improvement of our spelling by consulting the Simplified Spelling Board. All other agencies that make for a more careful, richer and more flexible vehicle of thought transference certainly should have the understanding if not the support, of the science instructor.

The Clark Teachers' Agency is to be congratulated on securing Dr. Henry Coe Culbertson to be manager of the Los Angeles Agency. Dr. Culbertson for eleven years was president of the College of Emporia, Emporia, Kans., and for two and a half years president of Ripon College, Ripon, Wis. During the World War he was chief of the Section of Cooperating Organizations in the U. S. Food Administration, lectured throughout the country under the direction of the committee on Public Information, and also lectured in the American camps in France. Dr. Culbertson has done much platform work, speaking to nearly four hundred thousand people in all parts of our country.

THE MEASUREMENT OF ABILITY IN GENERAL SCIENCE.

By G. M. Ruch,
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and
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In 1919 one of the authors[1] published a crude test for the measurement of accomplishment in general or elementary science. Strictly speaking, these materials were of the nature of lists of terms to be defined by the pupils rather than *tests* in the modern terminology of educational measurement. Three approximately equal forms of fifty items each were provided after a fairly adequate and comprehensive validation of a large number of terms obtained from the analysis of about twenty-five of the leading text-books in general science. In a second paper,[2] some rough preliminary norms were provided together with data on the correlation of the results of the tests with school marks and intelligence, etc. The final standardization of these tests was not attempted because of the fact that a high degree of reliability and complete objectivity of scoring could not be secured for tests in the form in which these had been devised and published.

The demand for these tests proved very much greater than could have been expected and has indicated the need for further work leading to the production of valid and reliable measures of ability in this subject which has shown such a remarkable growth all over the country in the past ten years. The present paper will present a brief account of the standardization of a revision and extension of the original *Range of Information Test in General Science.*

The revised tests are provided in two forms of approximately equal difficulty[3]. Each form consists of two parts. Part 1 includes fifty items of the information type designed to sample, as widely as possible in a limited amount of time, a fairly wide range of simple facts drawn from the fields of botany, chemistry, physics, zoology, astronomy, physiography, geology, and physiology. The facts involved call for knowledge of elementary scientific principles, terms, definitions, concepts, and applications. Seven possible responses are provided for each

[1]Ruch, G. M., A Range of Information Test in General Science, General Science Quarterly, 1919, 4, 257-262.
[2]Ruch, G. M., Range of Information Test in General Science: Preliminary Data on Standards, ibid., 1920, 5, 15-19.
[3]The Ruch-Popenoe General Science Tests. Published by the World Book Company, Yonkers, New York. The tables presented on the following pages are reproduced from the Manual of Directions for use with these tests.

question asked and the pupil is instructed to underline the correct responses. The use of seven responses has been adopted in order to reduce the chance element involved in tests of this type to a degree where it does not seriously militate against the reliability of the tests. A few examples will make clear the nature of these items.

1 The earth rotates on its axis once in 12 hours 24 hours 7 days 31 days 3 months 365¼ days 4 years
2 The greatest vertical height to which water can be siphoned is about 30 inches 10 feet 30 feet 40 feet 100 yards 1 mile 5½ miles
3 An organism which reproduces by means of spores is the maple Amoeba bread-mold sponge earthworm minnow cedar
4 The calyx is made up of the petals stamens petioles leaves pistils sepals stipules
5 The smallest of the planets is Mercury Venus Mars Jupiter Saturn Uranus Neptune

Part II of each form is designed to measure the ability of the pupil to identify apparatus, organisms, structures, principles, etc., and to apply such principles to the solution of simple problems. Twenty diagrams and drawings have been prepared together with completion exercises based upon these illustrations. Eighty blanks are provided for the answers of the pupils and most of the blanks admit of but one or very few correct answers. The scoring is practically completely objective. The use of illustrations is defended upon the basis of the need of avoiding purely linguistic test items. This is a common limitation of almost every test on the market today. Experience has shown that pupils respond with greater interest and effort to pictorial presentations of test materials. There is a further advantage to be found in the fact that diagrams are more directly related to the actual methods of laboratory teaching than are most science tests or traditional content examinations in use in schools generally. The following examples will serve to illustrate the method.

(A diagram of a lift pump without labels; the essential parts of the pump being indicated by letters). The text of the corresponding completion exercise reads:

a. This is a drawing of a (lift) (pump)
b. The piston is lettered (A)
c. The valve which opens on the upstroke is lettered (C)
d. The greatest distance that valve C can be placed above the level of the water at D, if the instrument is to work successfully, is about (30) feet.

(A pulley system is shown with two movable pulleys threaded with four strands of rope supporting the weight. A weight marked "100 lbs." is attached.)

The text of the corresponding completion exercise reads:

a. The mechanical advantage of this pully system is (4).
b. The rule for the mechanical advantage of any pulley system is that the mechanical advantage is equal to the number of times the cord passes to and from the (movable) pulley.
c. Disregarding friction, the force needed to lift the 100 pound weight shown is (25) pounds.

The correct responses in the above sample have been filled in and indicated by the parentheses. They do not occur on the test blanks.

The actual working time for the entire test totals forty minutes; Part I requiring 15 minutes and Part II 25 minutes. These times are purposely made very generous to insure the test being almost entirely one of power rather than speed. This makes it possible to give one form of the test within a class period of the usual length. About 90 per cent of ninth grade pupils can attempt every item of the test within the prescribed time limits. The score on Part I is the number of correct items and on Part II the number of correct completions divided by two, thus making the total possible score 90 points for both parts together.

The selection and validation of the individual items of these tests has been described at some length in the first paper cited. The reader is referred to this source for details. As has been stated twenty-three texts and laboratory manuals were carefully analyzed, page by page, and all terms used in these books were listed together with the total frequency for the entire series of texts. More than five hundred constantly re-occuring terms were found. Of these about one hundred eighty were common to at least half of the texts and were consequently considered as valid for test purposes. Further eliminations, for reasons stated in the references cited, reduced this number to one hundred fifty. These have been tried out upon several hundred pupils and two lists of fifty items each have been retained and used in the make-up of Part I of the two final forms. The method of selection of the diagrams was similar although not so rigidly carried out. Rather, it was decided to place more confidence in the ratings for merit by a number of experienced teachers of general science. Forty diagrams were finally selected, twenty appearing in each form.

It must be freely admitted that there are more desirable criteria for the validation of educational tests than the one here used. This statement is subject to certain reservations, however, particularly in new subjects which are subject to very

little standardization of contest. General science is a case in point. The great majority of schools use text books as a basis for such courses according to the several published studies on the methodology of general science. For this reason, the frequency of appearance of a fact in the current text-books is about as likely to be representative of the frequency of occurrence of this fact in general science courses throughout the country as can be determined by any simple method. It may ultimately be possible to provide a better criterion for evaluation.

Disregarding the original try-out of the *Range of Information Test in General Science*, the revised tests (known as the *Ruch-Popenoe General Science Test*) have been carried through two further try-outs. The preliminary one involved about two hundred fifty pupils representing a sampling of ten schools in five different states widely separated geographically. These results were used to obtain the per cent passing each individual item and for equating forms. The second try-out was held for purposes of determining reliability coefficients and obtaining further data on norms. Tentative norms based upon three hundred sixty-three pupils, representing twelve schools in a half dozen states, are now available. More reliable norms will soon be provided.

The following reliability coefficients have been computed by the correlation of the results of Form A with those of Form B. All coefficients are based upon the Pearson Product-Moment formula.

TABLE 1.
Reliability Coefficients for the Ruch-Popence General Science Test, Form A against Form B.

School	State	N	Part I only	Part II only	Entire test
1 Westinghouse	Penn.	48	.69	....	.81
3 University High	Oreg.	23	.76	.74	.87
2 Grand Rapids	Mich.	42	.64	....	.80
4 Palo Alto	Calif.	22	.78	.69	.85

Combining these separate reliability coefficients into a single average by weighting each according to the magnitude of N, the reliability of a single form becomes 0.82. By the use of Brown's formula $R(1+2) = \frac{2R_{12}}{1+R_{12}}$, the reliability of the sum or average of two forms can be estimated as about 0.90. If the reliability of a single score be assumed at 0.75 in the interests of conservatism, the reliability of the sums of both forms becomes 0.86.

The probable error of a single score in the sense of being able to estimate true scores (defined as the average of an infinite number of similar forms) from obtained scores in a single test can be computed from the formula

P. E. score = $.6745\,\sigma\,\sqrt{1-r_{12}}$ as 4.2 score points (the value $.6745\,\sigma$ being taken as $\frac{Q_3-Q_1}{2}$ or $\frac{44.6-24.9}{2}$ as obtained from the values for these percentiles in Table 3). Similarly, the probable error of a score obtained from the average of both forms of the test would be found to equal a little more than three score points.

Table 2 gives a general analysis of the subject matter incorporated in the tests in terms of the special fields of science from which the test items were drawn.

TABLE 2.

Analysis of Subject Matter.

1	Biological Science (botony, physiology, zoology, etc.)	30%
2	Chemistry	12%
3	Physics and mechanical applications	38%
4	Earth science, agriculture, astronomy, physiography, and geology	20%

TABLE 3.

Tentative percentile norms based on 363 cases.

90% of ninth grade pupils reach or exceed a score of	18.8	
75% of ninth grade pupils reach or exceed a score of	24.9	
50% of ninth grade pupils reach or exceed a score of	34.7	(Median)
25% of ninth grade pupils reach or exceed a score of	44.6	
10% of ninth grade pupils reach or exceed a score of	53.4	

It is believed that the tests described will prove of value to teachers of general science in a number of ways:

(1) In the assignment of school marks; by furnishing a more reliable and objective basis than that of the judgment of the teacher alone or by the use of the traditional methods of subject examinations which have been repeatedly shown to be very unreliable.

(2) In the determination of promotions and failures.

(3) In the classification of pupils into sections for the purpose of differentiated rates of progress or for the enrichment of the curriculum of the abler students. In this connection, it is strongly urged that a good intelligence test be given as well. Both educational achievement and general mental ability should be utilized in sectioning classes.

(4) In comparing results obtained by the teacher of a particular class with the accomplishment of similar classes in the same school or in other localities.

In connection with the last point raised, it may not be out of place to remind teachers that comparisons of educational test scores with published norms involves issues too frequently overlooked. In order that such comparisons can be taken at face value it is imperative that the ranges and levels of talent

be strictly comparable with the talent involved in the production of the test norm. It is impossible to draw correct conclusions from the fact that class X has an average score one, two, three, or more points above or below the published test norm unless it can be shown that strict comparability of talent exists between the two groups. It is at this point again that valuable date are to be had from the combined use of educational and mental measurements. Norms, in their turn, derive their validity primarily from the fact that they are based upon legitimate methods of sampling, and but secondarily, from the fact that large numbers are involved. Probably every important function of an educational test save one (the last discussed above) can be served in the absence of norms.

This statement is not offered as a brief for poorly standardized tests nor as an excuse for the admittedly tentative nature of the norms for the particular tests under discussion. It is a fact that is rapidly gaining the attention of workers in educational measurement. The present authors are very desirous of perfecting the tentative norms here published and will be very appreciative of the cooperation of users of these tests in reporting scores on the blanks provided for this purpose.

The real questions which should be raised prominently in the critical evaluation of the worth of an educational test should be in point of importance somewhat as follows:

(a) Has the test been adequately validated in the sense that it measures significant and crucial knowledge which can reasonably be expected to become a part of the pupil's more or less permanent acquisition in the field covered? This is another way of saying that a test should measure what it purports to measure.

(b) Is the test reliable? Does it measure reliably what it really does measure? How much confidence can be placed in the obtained scores in the sense that a second form of the test would give approximately identical results?

(3) Are there adequate norms? Do the norms represent a fair sampling of the abilities of pupils of the particular age, grade, or school classification? Are the norms mere composites of unsystematically obtained scores without reference to homogenous talent?

(4) Can the particular class or pupil be fairly compared with the norms upon a basis of strict comparability of the kinds of talent involved in each case?

A final statement might be made in the interest of another type of usefulness for the above tests. It has been found that these tests can be applied to pupils older than those normal to general science courses for certain general survey purposes. In fact, it was found experimentally that the tests would serve to differentiate among college students in liberal arts and general cultural courses in a fairly satisfactory manner. The rather

wide use of such range of information tests as those of Whipple indicates that even with adults it may be occasionally useful to get rough measures of general knowledge of particular fields such as literature, history, and science. As a sampling measure of familiar scientific concepts these tests may prove of some value outside of their specific aims and intended scope.

THE INTRODUCTION OF SCIENCE IN THE GRADES AS A FINANCIAL PROBLEM.

By Percy E. Rowell,

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One great objection to the introduction of science in the grades is the expense for special rooms, apparatus and supplies. To this must be added the higher salaries, or at least the additional salaries, of the special teachers, and probably the salary of the supervisor of science. If the course of science is to be worthy of the name it *must* be taught by the laboratory method; suitable space and material should be supplied. Unless the budget includes a proper sum for satisfactory equipment it would be better not to introduce science in the grades.

By satisfactory equipment is not meant the equivalent of that which is deemed necessary for high-school science. On the contrary, the successful science course in the grades must be simple, dealing with common things of everyday life. The pupils should not be overawed by the strangeness of refined scientific apparatus, nor should they feel that they are entering an operating room of a hospital every time they go into the science laboratory. For this reason a science course in the grades does not require so large an expenditure of money as is commonly thought by those whose experience is limited to the teaching of high-school science. Nevertheless, there is a necessity for certain equipment, and it is the purpose of this article to supply a plan whereby science may be introduced in the grades, both effectively and economically.

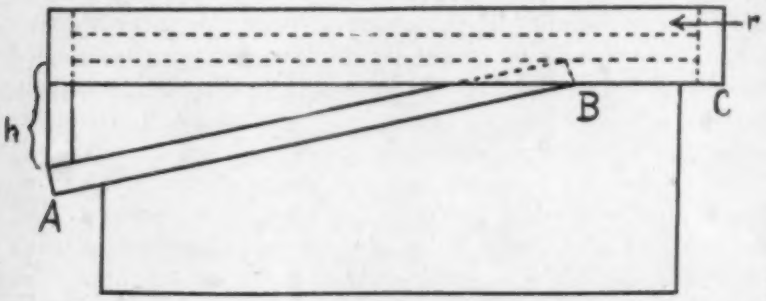
The Cost of a Laboratory.

Where possible, there should be a special room for the science work, properly fitted with water, gas, tables, shelves and all required equipment. The problem, however, is to introduce science work in a building now in use, and in the most economical manner which is compatible with success.

A laboratory should be considered very much as a study room, where, instead of using books as the only source of in-

formation, the thing itself is studied, and knowledge is obtained at first hand. What is more natural, then, than the suggestion that the study room be turned into a laboratory? It may happen, however, that some study rooms are entirely unsuitable for science work, and it is quite probable that all of the rooms are occupied all of the time. This requires that the science work be performed in the class room.

If the class room has movable tables and chairs it is well adapted for use as a laboratory. If, as is more often the case, each pupil has his chair and desk fastened to the floor, recourse must be had to the use of false tops for the desks, both to preserve them from injury and to obtain a level surface upon which the apparatus may be placed. The illustration shows how the tops may be made.



A-B-C is the top of the desk, (h) is the height to which it is necessary to raise the front of the false top to make it level, and (r) is the rim around the false top to prevent the apparatus from falling off, while the dotted lines represent the upper and lower surfaces of the top. The overhang at (C) will prevent the top from sliding off the desk. The material which is needed for one top is about five board feet of surfaced lumber. This would cost about fifty cents. The cost of manufacture would depend upon the method, whether in a factory or by hand. A carpenter can average making two tops per hour, or sixteen per day. If eight dollars per day is taken as the present pay for a carpenter, the cost of manufacture would be fifty cents, making the total cost one dollar. Since these tops will last for several years, and, since they would be used by several classes of pupils each day, the cost per pupil per year would be slight.

It is very desirable that the teacher have a demonstration table, in addition to the usual desk. A large kitchen table, painted black, with a dull finish, will serve very well. Such a

table, having a one-piece top 42″x26″, costs two dollars and a half. Two tables of this size, placed end to end, would make a very satisfactory place for performing some of the experiments for the class, and for showing them methods of work. Each table has a drawer which is useful for small articles.

If one of these tables could be fastened to the floor and piped for gas, it would enable the teacher to supply hot water for various experiments, as well as to show the class some of the effects of high temperature upon various substances. Illuminating gas is far better than alcohol lamps, but scientists made considerable progress before the use of gas, and also, there is not so much need for high temperatures and for large quantities of heat in the elementary science work as is required in high-school science. For these reasons, while gas is desirable, its use is not a necessity, and alcohol lamps may be used both by the teacher and the pupils.

The addition of a sink, built into one of the teacher's table, and connected with the water supply, would be found very convenient, although not absolutely necessary. However, there must be some source of water, together with a place into which the waste water may be poured. This sink may be in an outer hallway where it may be easily reached. The cost of this plumbing is hard to estimate except for a given locality.

The Cost of Apparatus.

The kind of science which is to be taught will determine to a great extent the cost of apparatus and supplies. If the science is to be limited to any one division of the subject, this limitation will defeat many of the advantages which may be obtained through its introduction in the grades. A briefer course may be economical in dollars and cents, but, unless the science course is general in its nature, and covers the whole field of science, those larger dividends of increased scholarships and better developed citizenry will not be realized.

To list the apparatus which would be required for two years of science, taught in this broader method, would take too much space, while the attempt to affix the cost to each article would be futile, because prices vary so much in different parts of the country. The mere length of the list does not indicate a large cost, however, for many of the articles are very cheap, while still others may be obtained for nothing. Much of the apparatus may be collected by the pupils, thereby giving them a feeling of cooperation in the science work. Thus bottles, sticks and stones

may be used to advantage, while the ubiquitous chalk box has literally a hundred uses. Bits of string and wire are useful for many purposes, and, in general, disdained junk of all kinds finds a ready use. Cardboard from old boxes, nails, cork stoppers, window glass, scraps of varied-colored paper and cloth, tin cans, old dishes, sawdust, sand and loam are all easily obtainable, as well as valuable for elementary, or introductory, science.

It may be said that science can not be taught properly by means of these common things. While it is true that much of the high-school science requires apparatus which is more or less refined, the point of view is different, the object being to specialize in one branch and to carry on the work in a somewhat quantitative manner. Introductory science may, as part of its advantages, pave the way for the more advanced study, but its chief purpose is to spread before the pupils a vast amount of simple phenomena, with such proper organization that they may develop the scientific attitude—not the attitude of the scientist. To do this in the best manner necessitates the use of that material with which they are the most familiar. The science of common things is the science for the mass of the people, and the study should be, for the most part, qualitative. There will be produced only a very few scientists each year, but a better appreciation of the reality of things will be a blessing to all the people.

In addition to these common things there must be some apparatus, even in the elementary science in the grades. Glass and rubber tubing, chemical glass ware, and such material as can not be prepared locally, must be purchased. In all, however, the total expense will not be very great. Of this apparatus a large amount may be manufactured in the manual training department or in the vocational department of the high school. Nevertheless, care must be taken to preserve a "hominess" in both the laboratory and in the apparatus, to the end that the attention may be focussed upon the scientific phenomena, rather than upon the scientific apparatus. Young children, and even some pupils in the high school, are liable to conside a piece of apparatus as a machine by which the laws of nature are made to act as they do. The making of the apparatus will help to remove this delusion.

There is one other expense which must not be overlooked: The teacher of science is compelled to do more work than the

[1]Courses devoted to instruction in the manufacture of apparatus from ordinary articles were given at the University of California by the author in 1917 and 1918.

teacher of any non-laboratory subject. The experiments must be planned, the apparatus must be distributed and stored again, and sufficient supplies must be kept on hand. For all this extra work the teacher should receive extra compensation, and this should be the same amount which is given to the laboratory teachers in many high schools—five dollars per month.

AN EXPERIMENTAL CLASS IN HIGH SCHOOL BIOLOGY.

By Winifred Perry,

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In the January, 1922, number of School Science and Mathematics there was published a brief account of an experimental Class in High School Biology that I was conducting in the Francis W. Parker School of San Diego. There was nothing particularly new or outstanding in the method used, except that the students themselves supplied their own motive power for their various activities. Since then there have come various inquiries as to this form of highly individualized project work which was suggested to me by Professor J. L. Meriam of the University of Missouri. These inquiries have been of two types, first as to the nature of the projects submitted to the students, and second as to the amount of work accomplished by these students in the year's course. To answer these questions and to urge other teachers to try out the method is the purpose of this second paper.

The list of projects submitted to the class is not given in its entirety for it is too long a list for this paper. Of this list some fifty projects are printed that the reader may know something of the type of problems which were presented to these boys and girls of simply average ability. Many of these topics will be merely suggestive for inland localities, but substitutions stressing local features may easily be supplied. In this paper the projects have been grouped into four types. (1) collection and identification, (2) experiment, (3) reading and (4) dissection. In the class room they were not so classified. The term project is here used to connote a purposeful activity which the pupil carries to a successful conclusion.

Biology Projects.

1. To identify and study the habits of ten game birds of this vicinity. (1)
2. To investigate California's policy of bird conservation. (3)
3. To learn habits of birds by making a collection of ten abandoned nests. (1)

4. To study nesting and feeding habits of 15 birds of this locality. (1) (3)
5. To learn how birds affect the orchard. (3)
7. To learn life history and control of citrus scale. (1) (3)
8. To discover why insects visit flowers. (3) (1)
15. To study grasshoppers in their relation to crops. (3)
22. To make a collection illustrating life history of frog or toad. (1)
24. To make a balanced aquarium. (2)
27. To illustrate by use of diagrams why the so-called horned toad is misnamed. (3)
29. To determine the rate of growth in stems using an auxanameter. (2)
34. To find what kinds of soil hold water best. (2)
37. To determine the effects of cotton-seed meal, stable manure and fish scrap on beets. (2)
38. To determine the effect of nitrate of soda on the growth of lettuce. (2)
40. To learn through experiment what factors are necessary for seed germination. (2)
41. To learn what food substances are found in seeds of corn and bean. (2)
46. To determine the effect on the crop of fumigating seed potatoes. (2)
50. To make a graph showing the rain-fall in San Diego county for the past ten years and compare the crops year by year for that period with the amount of precipitation. (3)
52. To make Bordeaux mixture and test its value in the school garden. (2)
57. To learn through experiment the three functions of leaves. (2)
67. To make a collection of 5 pine cones and study the trees producing them. (1) (3)
68. To make a collection of 15 seeds showing methods of dispersal. (1)
69. To collect leaves, flowers and if possible the fruit of 10 species of Acacia. (1)
80. To collect and identify 10 species of sea-weed. (1)
81. To identify and study 5 species of fresh water algae. (1)
83. To collect and identify 30 spring flowers. (1)
86. To learn principles of landscape art and observe their application in parks of San Diego. (3)
89. To collect and identify 10 Autumn weeds. (1)
92. To make a map showing areas and types of California's forests. (3)
94. To learn habits and characteristics of 10 food fishes found off the California coast. (3)
96. To collect and identify 15 sea shells. (1)
104. To determine by experiment under what conditions bacteria grow best. (2)
105. To prove by experiment the value of given disinfectants. (2)
107. To compare the typhoid rate in San Diego with other cities of about the same size. (3)
109. To investigate and report on the duties of the San Diego health department. (3)
116. To know the chief contributions to humanity of 10 biologists. (3)
118. To diagram life history of blister blight of pine. (3)
121. To make a chart showing food values in various foods. (3)
122. To learn by analysis why milk is a perfect food. (2)
123. To collect and identify 10 small marine animals. (1)
136. To successfully can by the cold-pack method a chosen fruit or vegetable. (2)
138. To make a collection of soil types of this locality. (1)
142. To collect and identify ten specimens of fleshy fungi. (1)
145. To study the causes and methods of prevention of tuberculosis. (3)

147. To collect and identify 10 species of our chaparral. (1)
150. To investigate the quarantine laws of California. (3)
153. To learn the effects of tonsils and adenoids on the health of school children. (3)
157. To grow a crop of lettuce successfully. (2)
158. To grow a crop of beets successfully. (2)
161. To learn the life history and control of the codling moth. (3)
172. To find out how the government propagates food fishes. (3)
177. To successfully grow cuttings of geranium or perwinkle. (2)
189. To isolate bacteria from the soil and study their characteristics.

(2)

After an examination of the list of projects the reader will see that they are very unorganized and in my own classes I shall continue to keep them so. Some students have the idea that they want to study botany only, or human physicolgy, or zoology. By having the botanical subjects interspersed with physiological, and physiological with zoological subjects, a better balanced course is assured. Like their elders, boys and girls have a fair amount of curiosity and they desire to explore the unknown. Often the reason given for choosing a certain subject was "curiosity" or "I wanted to know what that new word meant." Thus a wider distribution of subject-matter per individual student is gained by not grouping all of the topics of one kind together.

To answer the second question as to the amount of work covered in the year's course I have checked the work done by ten students with the tables of contents of Hunter's Civic Biology and of Gruenberg's Elementary Biology. The subjects marked by an x in the following tables have been investigated independently by the students themselves. A study of these tables reminds one that in any group, large or small, there are marked individual differences. This method allows the student having greater ability to go ahead, and he is not retarded by the majority of his class, as is too often the case with very superior pupils.

CONTENTS OF HUNTER'S CIVIC BIOLOGY.

	1	2	3	4	5	6	7	8	9	10
1. Some reasons for study of Biology.	X	X	X	X	X	X	X	X	X	X
2. Environment of plants and animals.	X	X	X	X	X	X	X	X	X	X
3. Interrelations of plants and animals.	X	X			X	X	X		X	
4. Functions and composition of living things.	X	X		X	X	X			X	
5. Plant growth and nutrition—the causes of growth.	X			X	X	X		X		X
6. Organs of nutrition—the soil and its relation to roots.		X		X	X		X	X	X	
7. Plant growth and nutrition—plants make food.	X	X	X		X	X			X	X
8. Plant growth and nutrition—circulation										

and final use of food by plants.	X	X		X	X	X				X
9. Our forests, their uses and the necessity of their protection.							X	X		
10. Economic relations of green plants to man.	X	X	X	X	X	X	X	X	X	X
11. Plants without chlorophyll in their relation to man.	X	X	X	X	X	X	X	X	X	X
12. The relations of Plants to Animals.	X				X		X		X	X
13. Single-celled animals considered as organisms.	X	X	X	X	X	X	X	X	X	X
14. Division of labor, the various forms of plants and animals.	X	X		X	X	X			X	X
15. The economic importance of animals.	X	X	X	X		X	X	X	X	
16. An introductory study of vertebrates.	X		X	X	X				X	
17. Heredity, variation, plant and animal breeding			X			X	X	X	X	
18. The human machine and its needs.	X	X								
19. Foods and dietaries.	X	X	X	X	X			X	X	X
20. Digestion and absorption.	X	X	X	X			X	X		
21. The blood and its circulation.		X	X				X	X		
22. Respiration and excretion.				X		X				
23. Body control and habit formation.			X			X	X	X	X	X
24. Man's improvement of his environment.	X	X	X	X	X	X			X	
25. Some great names in biology.		X	X			X	X			

CONTENTS OF GRUENBERG'S ELEMENTARY BIOLOGY.

Part I, The World in Which We Live.

Chapter.	1	2	3	4	5	6	7	8	9	10
1. Introduction.										
2. What Goes on in the World.										
3. Fire.										
Part 2, Life Processes of the Organism.										
4. Living Things and non-living Things.										
5. The Living stuff.	X			X	X				X	
6. The Conditions of life.	X	X	X	X	X	X	X	X	X	X
7. Air and Soil in relation to sprouting.		X		X				X		X
8. Seeds and seedlings.		X		X	X	X		X	X	X
9. External forces and plants.	X				X					
10. Absorption from the environment.	X								X	
11. Roots of plants.	X	X		X	X			X	X	X
12. What food is.	X	X	X	X				X		
13. The origin of food.										
14. The chemical cycle of life.		X	X	X		X	X		X	
15. The soil as source of our materials.	X	X			X		X	X	X	X
16. The leaf as starch factory.		X			X			X		X
17. Our dependence upon leaves and chlorophyl.		X			X			X		X
18. Starch-making and digestion.										X
19. Digestive system in man.	X		X	X			X			
20. Health and food standards.	X		X	X						
21. Food requirements.	X	X	X	X	X			X		X
22. Food and dietaries.	X	X	X	X				X		
23. Food habits.	X	X	X	X				X		
24. The social side of the food problem.		X								
25. Stimulants, narcotics and poisons.						X	X	X	X	X
26. Alcohol and health.						X	X		X	
27. Alcohol and society.						X	X		X	
28. Air and life.										
29. Breathing in man.				X			X			
30. Ventilation.										
31. Contaminated air.										

32. First aid and hygiene in relation to breathing.										
33. Transfer of materials in plants.	X	X			X	X				
34. The blood.							X	X		
35. The circulation of the blood.										
36. Hygiene of the circulatory system.										
37. The blood as a living tissue.							X	X		
38. Wastes and by-products of organisms.			X	X	X	X			X	
39. Hygiene of excretion.						X				
40. Excretion and fatigue.										
41. Fatigue and the worker.										
42. Nerves and the reactions of organisms.	X			X			X		X	
43. Tropisms and the beginnings of sense.	X					X			X	X
44. Eyes and light.			X			X	X			
45. Hygiene of the eyes.			X			X	X			
46. Sound sensations.										
47. Responses to gravity.										X
48. Instincts.										
49. Habit.										
50. Chemical injury to the nervous system.						X				
51. Unity of life.										
52. Growth and regeneration.		X			X	X				
53. Development.					X					
54. Conditions for development.										
55. New organisms.										
56. Sex.	X	X	X	X	X	X	X	X	X	X
57. Flowers.	X	X		X	X	X	X		X	X
58. Pollenation.	X	X		X	X	X	X		X	X
59. Adaptations of flowers.	X	X		X	X	X	X		X	X
60. Fruit and seed distribution.				X	X					X
61. Alternation of generations.								X	X	
62. Reproduction in animals.				X	X					
63. Infancy and parental care.					X					
64. Obstacles to life.			X							
65. The conflict of life with life.			X			X				
66. Protective armors and organisms.										
67. Protective Pigments and Appearances.										
68. Protective movements.										
69. Protective activities.										
70. The forest in relation to man.				X		X		X		
71. Bacteria and health.	X	X	X	X		X	X	X	X	X
72. Control and use of bacteria.		X	X	X	X	X	X	X	X	X
73. Insects as spreaders of disease.	X			X		X	X			
74. Insects as intermediate hosts.	X					X	X			
75. Insects and human wealth.	X	X	X	X				X		
76. Insects and other organisms.		X					X			X
77. Birds in relation to man.	X			X				X		
78. Social life of organisms.				X						
79. Variation.							X	X	X	
80. Heredity.			X			X	X	X	X	
81. Applications of principles of heredity.			X			X	X	X	X	
82. Heredity and protoplasm.			X			X	X	X	X	
83. Evolutiom.			X			X	X	X	X	
84. Applications and theories of evolution.			X			X	X	X	X	
85. The classification of organisms.				X						
86. Kinds of plants.	X					X				X
87. Kinds of animals.	X	X			X				X	X
88. Man and his relatives.				X		X			X	
89. Man's brain.							X	X		X
90. Man's conquest of Nature			X			X	X		X	
91. Science and civilization.		X	X			X	X		X	

It will be noted that no one student alone covered the entire

range of subject-matter as is given in these two texts. But the seminars or discussion periods when all contributed to the conference supplied any deficiency. In Professor Eikenberry's, "The Teaching of General Science," we find on p. 80, this statement: "From the nature of these projects and because of their individualistic character, they cannot constitute the background of a science course, but must be secondary and accessory. In this class the individualized work was strengthened by the socializing agency of the frequent discussions, and the class as a whole acquired the traditional material that is usually given in a class conducted as a recition group, plus the detailed studies or researches which they made independently. At the close of the year several comprehensive examinations were given and the results were very gratifying.

The most common objection thst is raised against this method is that it can only be successful when used in relatively small groups. In the October, 1921, number of SCHOOL SCIENCE AND MATHEMATICS, a course in Geometry given in the Fresno High School is described. This work is highly individualized and a group of fifty or sixty students is taken care of at one time by two instructors being assigned to the group. This same scheme was used last year in the general science class, the teacher of the physical sciences cooperating with me in this work. The same principle should work out well in a large biology class as it has in Geometry and general science classes, and undoubtedly would.

MANGANESE DEPOSITS OF EAST TENNESSEE.

The metals that are used in making hard or tough steel alloys came prominently into view during the World War, when the United States Geological Survey, Department of the Interior, made wide search for deposits of the ores of tungsten, vanadium, and manganese, which are commonly used in steel alloys. The most abundant of these metals is manganese, ores of which occur at many places in the United States. The interest in manganese still continues, especially as the tariff bill of 1922 placed a high duty on imports of manganese, which may make it profitable to mine some of the numerous unmined deposits in this country.

A report on the deposits of ores of manganese in East Tennessee, by G. W. Stose and F. C. Schrader, has just been published by the Geological Survey as Bulletin 737. This bulletin, which was prepared in cooperation with the Tennessee Geological Survey, is accompanied by a geologic map of East Tennessee, which shows the formations that contain the ore and includes a list of the mines and deposits in this part of the state. Each deposit is described in detail and is accompanied by a sketch map and sections, and some of the more productive mines are illustrated by detailed geologic maps that may be of special service to mine owners or investors. The bulletin shows the relation of the ore to the rock formations, describes the mode of origin of the deposits, and includes pictures of specimens of manganese minerals.

A HIGH SCHOOL COURSE IN ELECTRICAL ENGINEERING.

By H. M. Morley,

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The electrical engineering course in the Polytechnic High School in Los Angeles is the result of an evolution during many years. It is based upon a belief that a high school graduate is best fitted for modern commercial life by a broad, general training with a continuous application to the subject which is to be his life work. From the time he enters in the B-9 grade until he graduates, he is never taking less than seven periods a week of electricity, but care is taken to avoid the idea of the trade schools that produce trained artisans without either a broad education or a comprehensive theory of their trade. It is believed that a generous amount of hand work and laboratory experiments should go with the theory presented; but the aim of the manual work is to amplify and reinforce the principles rather than to make skilled workmen. There will be plenty of time in the years to come for boys to grow into skilled men, but if they do not get their theory in school, few will ever get it.

Los Angeles has sixteen high schools, of which Polytechnic with its enrollment of 2,600 is one of the largest. The pupils in the electrical course come from all parts of the city, and some come from neighboring cities by special arrangement. At present there are 97 in the B-9 entering term and 24 in the A-12 graduating class; the numbers in the other terms vary between so that altogether there are 400 in the course. Believing that the work we are doing is sufficiently out of the ordinary to be of interest to progressive school people, the course is described in some detail. In order to show that it is well rounded and that, breadth is not sacrificed for a specialty, the other work taken will first be enumerated, and the number of credits received in each indicated: Music, 1; English, 4; Mathematics, 8; Mechanical Drawing, 5; Machine Shop, 2; Chemistry, 2; History and Civics, 2; Electricity and Physics, 8. Physical training, chorus, hygiene, and first aid are carried in all courses without credit.. One credit equals one-half unit of college reckoning; that is, it represents a subject carried for five or more periods a week for one term or half a year. Foreign language has been omitted, which is along the line of the recommendation of the Mann*

*"A Study of Engineering Education," C. R. Mann, (Carnegie Foundation). "No provision is made for foreign languages in the curriculum just suggested. They have been omitted because three-quarters of the 1,500 practicing engineers who replied in writing to a question on this subject agreed that they had never found foreign languages essential to their professional careers, and half of them thought that they should not be required. In addition, there is a growing conviction among the schools that for students of engineering the time now spent in college on foreign languages may be much more profitably spent in other ways."

report for engineering schools. Those students going to college and desiring to take a foreign language, do so by omitting some of the drawing, machine shop, or electricity, as seems best in the individual case.

No existing text-books seem to go thoroughly into the fundamentals of the physical theory of electricity without bringing in mathematics incomprehensible to a high school student. Therefore, the subject matter is presented to the class by the teacher, and each student builds up his own text-book in his note-book as the work progresses. However, as the classes do not exceed thirty pupils, the recitation period becomes an informal discussion and should not be thought of as a formal lecture. The Lefax Company's system of notes is used throughout the course, reports being written up on their printed forms, and their data sheets used for wiring tables, formulas, symbols, trigonometric functions, etc.

The details of the specialized part of the work will be described in the order taken:

B-9 term, Electricity and Wiring, 14 periods a week. The entering student is at once introduced to the engineering work he is to pursue, instead of being kept from it a year or two as is the case in many engineering courses; this also is in keeping with the recommendations of the Mann report. Electricity and wiring each have three single periods a week of recitation, and two double periods of laboratory. In electricity the regular direct current subject-matter is covered, including magnetism, static electricity, magnetic effect of current, condensers, Ohm's law, cells, series and parallel resistances, etc. The experiments follow the "Direct Current Laboratory Manual" by H. La V. Twining, Head of the Department at Polytechnic, and are of the usual kind, with perhaps one exception; the relationship between static and current electricity is plainly shown by grounding one terminal of a sensitive galvanometer and bringing a charged rod toward the other terminal; the explanation of the resulting deflection drives home many points of the theory. The work of this term in wiring is spent on low voltage systems, bells, return call circuits, annunciators, interconnecting telephones, etc. Although many kinds of circuits are installed in an approved manner, the aim is to learn the circuits rather than to spend excessive time practicing installations. This work is carried on in a specially constructed two-story building containing forty small rooms, the partitions of which are not lathed

and plastered, so that the wires may be run through the studding as in a building under construction.

A-9 term, Electricity and Wiring, 14 periods a week as before. In the second term of high school the student is plunged into enough of the theory of alternating current to make him realize that electrical engineering is no course for the person who cannot handle his mathematics. Starting with the laws of induced currents, the phase relationships in circuits containing resistance and reactance is developed. The effect of inductance and capacity is studied and problems worked for both series and parallel circuits. As trigonometry is not taken until the 11th grade, it is necessary to teach the sine and cosine functions in the electricity class, so that the required mathematics may be available. The laboratory work keeps abreast of the recitations and follows Mr. Twining's "Alternating Current Laboratory Manual." Starting with the regular induction experiments, the work progresses so that at the end of the term the student is making measurements on circuits containing resistance, inductance and capacity in series or in parallel, and showing the phase relationships involved by vectors and sine curves. Intermediate experiments study the use of the capacity bridge, inductance bridge, integrating wattmeter, etc. Beginning with this term the student is required to print his reports on experiments in order to practice the lettering learned in mechanical drawing. The time in wiring is devoted to 110 volt installations; both knob and tube work and pipe work are put in according to the Underwriters' Rules, but again the aim is to learn to figure the circuits and wire sizes rather than mere practice in following orders.

B-10 and A-10 terms, Physics and Auto Electrics 14 periods a week as before. The year in physics is covered in the conventional manner except that electricity is omitted because the student has already had more of that than is given in a high school physics text-book; the six weeks gained by this omission is used for additional drill in the chapters on mechanics. The object of the year in Auto Electrics is two fold: first, to give the student an understanding of that very common application of electricity to modern life which may easily prove of vocational advantage; second, to keep the electrical feature of the course continually present. so that by reiteration for four years the fundamental principles may make an indelible impression. Various systems of ignition, starting, and lighting for auto-

mobiles are studied, using Haywood's handbook and Dyke's encyclopedia for reference books. Although many makes of automobile generators and starting motors are examined and tested, it is the underlying theory and the learning of circuits that is particularly stressed. Each boy does enough armature winding to get the idea of it, but no attempt is made to produce a finished product. Storage batteries are charged, overhauled, rebuilt, and built up from new parts.

B-11 term, Direct Current Calibration, eight periods a week, two single periods of recitations and three double periods of laboratory. With a background of two years of electricity and physics, the student begins work ordinarily pursued in college. The physical conception of units, processes, and laws, are thoroughly considered, but the mathematical treatment of them cannot go beyond the trigonometry. The relationship of the absolute units, both electrostatic and electromagnetic, are worked out and the factors for converting them into practical units determined. Two experiments have been very fertile for this purpose, the determination of the mechanical equivalent of heat by dropping shot down a tube, and the determination of the electrical equivalent of heat by a coil in a calorimeter; by combining the results of these two, all of the electrical constants such as 10^8, 10^9, and $3x10^{10}$ are brought out. The absolute value of one volt is obtained by weighing the force on an electrostatic voltmeter. The absolute value of one ampere is measured by a tangent galvanometer, the oscillation of a suspended magnet, and its attraction for a magnetic compass. By measuring the resistance of a wire at different temperatures, it is found where the absolute zero of temperature would be if the temperature coefficient were constant. A standard voltmeter and ammeter are calibrated with the potentiometer, and portable meters are calibrated by the standards and correction curves made. Other experiments performed study the Kelvin bridge, pyrometer, copper and silver voltameters, and the relationship between ampere-turns and pounds pull of an electromagnet. During the recitation periods the theorectical side of the above work is discussed, and a little computation is done on the electrical part of the design of the armature and field of a direct current generator. Although the work of this term is primarily calibration, the question of the precision of a series of measurements is not considered, and nothing is said about probable error, average deviation, or other deviation measures.

A-11 term, Advanced Calibration, eight periods a week. The work of this term is a continuation of the previous one and emphasizes the testing of alternating current instruments and a study of electrochemistry. A "B and H" curve is plotted for a sample of iron, and the hysteretic constant measured; the Carey Foster bridge is studied and used; alternating current voltmeters ammeters and wattmeters are calibrated with the Rowland dynamometer; the temperature coefficient of the resistivity of a wire at high temperatures is found by means of an electric furnace and pyrometer; resonance curves are plotted for inductance and capacity in parallel, and also for them in series. Much time is spent on the electrochemistry of electrolytes, and the conductivity of them at different degrees of dilution is determined by the voltmeter-ammeter method, which is perhaps a unique way of making this measurement; curves of the conductivity of an acid, a base, and a salt are plotted showing the point of maximum conductivity lying between the extremes of a saturated solution and pure water. A quantitative study is made of the relations that exist when water is decomposed by electrolysis. The recitations follow along with the laboratory, and also bring in a little on the design of a transformer and the electrical part of an alternating current generator.

B-12 term, Direct Current Machinery, 8 periods a week. The machines available for this work are: a 125 volt 40 ampere compound generator with commutating poles, direct connected to an induction motor; a 230 volt 30 ampere Dobrowolsky 3-wire compound generator; a 110 volt 91 ampere shunt wound double-current generator, (6-phase on the alternating current side); a 125 volt 4 ampere compound generator. Using the series winding alone as a series generator, makes it possible to take complete characteristic curves for shunt, series, and compound machines. Efficiency is obtained by brake test and by stray power method. This work is of regular college grade and follows the Laboratory Manual by Seaver and Townsend. Reports are written up and curves neatly plotted; care is taken to include name-plate data of machine and serial numbers of instruments used during the test, but no great stress is laid upon accuracy of results; that is, meters are not regularly calibrated and no corrections are applied to observed readings, and a generous deviation is permitted. Again the idea is to get the student familiar with the operation of dynamo-electric machinery and the methods of testing it, without the refinements that are a

part of actual commercial work. The theory involved in the various experiments is discussed in the recitation periods, and many illustrative problems are worked, including armature winding.

A-12 term, Alternating Current Machinery, eight periods a week. The machines available are: three 3-phase induction motors; a 6-phase alternating current generator stator with four different rotors; the previously mentioned double-current generator which serves as a synchronous converter; numerous transformers. Using Bedell's Laboratory Manual as a guide, tests are made covering 3-phase circuits, generator characteristics, synchronizing, the induction motor, including the circle diagram, and the transformer. The recitation work parallels the laboratory, but owing to the lack of a knowledge of higher mathematics, the phenomena are studied as far as possible graphically by vectors rather than by mathematical methods. For example, the transformer is studied by Steinmetz's complete vector diagram, and the induction motor from the circle diagram. Each student gives a talk on a live engineering topic which broadens the horizon of the whole class and develops an interest in commercial applications.

Such is an outline of the course in electrical engineering as given at Polytechnic High School, and as has been said, it is an evolution. At present the Los Angeles school system is partly on the 8-4 basis (8 years in the grammar school and 4 years in the high school) and partly on the 6-3-3 basis (6 years in the grammar school, 3 years in the junior high school, and 3 years in the senior high school); those students on the latter basis have to make special adjustments in order to fit into the four-year electrical course. However, in general, everything works together with wonderful success. The large assortment of meters, the varied apparatus, the wiring building, the commercial experience of all the teachers, the location of the school in an intensively electrified community, all combine to produce worth while results. Another important thing is that the students like the whole plan, and when it has been suggested that their work could be lightened by omitting the Wiring or the Auto Electrics from the required course, they have almost unanimously voted against such a reduction. It will be noted that a study of radio is not included; this is because experience has shown that the interest of the boys centers in the construction of a set to play with rather than a serious consideration of the principles involved.

Although only the electrical part of the work has been described in detail, it must not be forgotten that the academic side has been carried along at the same time as has been indicated, so that the cultural phase of education is not neglected. Graduating students entering the electrical field forge ahead of their less fortunate co-workers. Those entering college in the electrical course find the work there easier than graduates of other high schools; some of our students in going to college take a mechanical or civil course there so as to broaden their engineering training and to avoid repeating so many of their electrical experiments. This does not imply that they remember all that was told them, or that if they did they would have a college education. It does, however, strengthen our belief that in the time available we have given them the best possible training with which to fight this world's battles.

THE APPLICATION OF THE ELECTRON THEORY TO THE WRITING OF CHEMICAL EQUATIONS.

By Walter O. Walker,

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In a previous paper the writer has outlined a method through which the Electron Theory is applied to the formation of compounds and the derivation of proper formulas. In the present article the Electron Theory will be applied to the writing of equations representing chemical reactions.

According to a modern High School text there are six general types of chemical reactions:

I. Simple Decomposition.
II. Direct Combination or Synthesis.
III. Simple Replacement.
IV. Double Decomposition.
V. Oxidation and Reduction.
VI. Reversible.

The authors of this same text further state that before writing an equation we must know:

1. That the change takes place.
2. What substance are involved.
3. What the products are, and
4. The formulas for all substances involved and all the products.

As previously pointed out a consideration of the Electron Theory will not only show (1) that the change takes place (in simple synthetic reactions) but will show also (3) what the products are; and (4) the formulas for all substances involved and all products. Considering these facts the only essential statement is (2) what substances are involved.

Continuing the authors of this text outline a method for the writing of all types of equations:

1. Write on the left the formulas of each of the substances taking part in the reaction.
2. Write on the right the formula of each substance produced.
3, 4, and 5 are omitted from this discussion and the Electron method for balancing equations substituted.

The procedure using the Electron Theory is (applied to the formation of water from Hydrogen and Oxygen).

1. H_2+O_2
2. $H_2+O_2 \rightarrow H_2O$
3. Assign electron values (electron gained or lost to all of the atoms or molecules.

$$\begin{array}{cccc} & \text{loses } 2e & & \text{gains } 4e \\ & H_2 & + & O_2 \rightarrow \end{array}$$

4. By taking small whole numbers multiply one or all of the atoms or molecules, making the electrons lost equal to the electrons gained.

$$\begin{array}{cccc} & \text{loses } 2\ (2e) & & \text{gains } 4e \\ 2H_2 & & + & O_2 \rightarrow 2H_2O \end{array}$$

5. Check up to make sure that all of the atoms and molecules are accounted for.

Simple Decomposition.

1. $H_2O \rightarrow$
2. $H_2O \rightarrow H_2+O_2$
3. $\quad\quad\quad 2e \quad 4e$
   $H_2O \rightarrow H_2+O_2$

This reaction is brought about by electrolysis. The excess of electrons on oxygen are neutralized while hydrogen is supplied with electrons. This changes them both to the elemental state. For the sake of simplicity the reaction is treated as one in which the electrons acquired by the Oxygen in the original formation reaction is returned to the original hydrogen.

4.
$$\begin{array}{cccc} & & \text{loses } 2(2e) & 4e \\ 2H_2O & \rightarrow 2H_2 & + & O_2 \end{array}$$

This arrangement will require the 2 H_2O which is placed on the left.

5. A check of the atoms proves that they are all in use in the reaction.

Direct Combination or Synthesis.

1. $Hg+O_2 \rightarrow$
2. $Hg+O_2 \rightarrow HgO$
3. $\quad 2e \quad 4e$
   $Hg+O_2 \rightarrow HgO$
4. $2(2e) \quad 4e$
   $2Hg+O_2 \rightarrow 2HgO$

1. $P+O_2 \rightarrow$
2. $P+O_2 \rightarrow P_2O_5$
3. $\quad 5e \quad 4e$
   $P+O_2 \rightarrow P_2O_5$
4. $4(5e) \quad 5(4e)$
   $4P+5O_2 \rightarrow 2\ P_2O_5$

Simple Replacement.

1. $Zn+HCl \rightarrow$
2. $Zn+HCl \rightarrow ZnCl_2+H_2$
3. $2e \quad 1e$

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

In this reaction the Zn replaces the hydrogen of the HCl. Zn will lose 2 electrons. Hydrogen has lost 1 electron in order to form HCl. It must then regain 1 electron before being set free in the elemental state. Since Zn loses 2 electrons, and one HCl molecule requires 1 electron to set free the hydrogen, 2 HCl must be taken. In other words the replacing element (or atoms of the element) must have the same electron value.

1. $H_2O + Fe \rightarrow$
2. $H_2O + Fe \rightarrow Fe_3O_4 + H_2$
3. needs 2e loses 2e & 2(3e)
$$H_2O + Fe \rightarrow Fe_3O_4 + H_2$$

In this reaction we have two Fe atoms losing 3 e each and one Fe atom losing 2 e. Therefor step three should be:

$$\overset{2e}{H_2O} + 3\,\overset{8e}{Fe} \rightarrow Fe_3O_4 + H_2$$

4. $4H_2O + 3\,Fe \rightarrow Fe_3O_4 + 4H_2$

Double Decomposition.

In this type of reaction, which might in most cases better be called Double Replacement, compounds are split up into atoms or molecules with electrical charges (Ions). The reaction consists primarily in the double replacement of one metal for the other.

1. $HCl + CaCO_3 \rightarrow$
2. $HCl + CaCO_3 \rightarrow CaCl_2 + H_2CO_3$
3. $\overset{1e}{H}Cl + CaCO_3 \rightarrow \overset{2e}{Ca}Cl_2 + H_2CO_3$

Since there is no apparent passage of electrons, but simply a union of ions, we must therefor, in order to have the reaction take place, have the electron values of the metals equal.

4. $2\,\overset{2(1e)}{H}Cl + \overset{2e}{Ca}CO_3 \leftarrow CaCl_2 + H_2CO_3$

In the above reaction the Ca and H have changed places and combinations. In order that this change take place the electron values of Ca and H must be equal.

1. $NaCl + H_2SO_4 \rightarrow$
2. $NaCl + H_2SO_3 \rightarrow HCl + Na_2SO_4$
3. $\overset{1e}{Na}Cl + H_2SO_4 \rightarrow \overset{2e}{H}Cl + Na_2SO_4$
4. Equalizing the electron values gives:
$$2\,\overset{2(1e)}{Na}Cl + \overset{2}{H_2}SO_4 \leftarrow 2\,HCl + Na_2SO_4$$

Oxidation and Reduction.

An Oxidation always accompanies a Reduction. The two are inseparable since they are brought about by the passage of electrons from the reducing material to the material reduced.

1. $CuO + H_2 \longrightarrow$

2. $CuO+H_2 \longrightarrow Cu+H_2O$
3. needs 2e gives 2e
   $CuO+H_2 \longrightarrow Cu+H_2O$
4. The Cu has gained 2e from the H_2. This gives the element Cu and the resulting combination of H_2 and O, forming H_2O.

The Cu has been reduced (gained electrons) while the H has been oxidized (lost electrons).

When $FeCl_2$ is oxidized to $FeCl_3$, one electron is lost from the Fe atom. When $FeCl_3$ is reduced to $FeCl_2$ one electron is gained by the Fe atom. A reducer must supply electrons, while an oxidizer must absorb electrons. Carbon readily supplies electrons when heated to the proper temperature, therefor it is a good reducing agent. Nascent Hydrogen readily supplies electrons, therefor it is a good reducing agent. $KMnO_4$ and $K_2Cr_2O_7$ (in acid solution) are strong oxidizing agents because of their ability to absorb electrons thru the high positive valence of Cr and Mn in these compounds in acid solution. The addition of strong acid renders the Mn and Cr more pronouncedly positive (causes them to be ionized as bases.

$$HMnO_4 \longrightarrow (HO)MnO_2 \xrightarrow{+3\,HOH} Mn(OH)_7$$

$$\xrightarrow[+++]{++++} Mn \longrightarrow 7(\overline{OH})$$

$$H_2CrO_4 \longrightarrow (HO)_2CrO_2 \xrightarrow{+2\,HOH} (HO)_6Cr$$

$$\xrightarrow[+++]{+++} Cr \qquad \longrightarrow 6(\overline{OH})$$

The basic ionization of these acids causes the Mn and Cr to become strong oxidizing because the positive charges are bared allowing the electrons to be neutralized more easily. This action is the equivalent of the absorption of electrons.

For further discussion of this important relation, together with experimental verification, see Stieglitz, "Qualitative Chemical Analysis," part 1, Chap. XV. A portion of the foregoing material has been developed from suggestion in this text.

Reversible Reactions.

Reversible reactions depend much upon external conditions. For example:

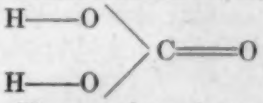
$$H_2O+CO_2 \longrightarrow H_2CO_3$$

is caused by dissolving CO_2 in water under pressure. A chemical action results in the formation of H_2CO_3. A release of the pressure on the surface of the liquid results in the reversing of the reaction and the breaking down of the H_2CO_3.

$$H_2CO_3 \longrightarrow CO_2+H_2O$$

An increase in temperature will bring about the decomposition of H_2CO_3. We explain the above reaction on the grounds of the instability of the H_2CO_3.

We assume the structural formula for H_2CO_3 to be

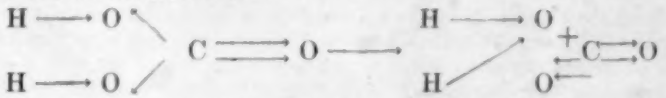


in which each of the H atoms have lost one electron to each O atom. Carbon has lost 4 electrons, 2 to one O atom and one to each of the other O atoms. Since C loses two electrons to one O atom there is no reason not to assume that under the proper conditions its two other electrons would not go to a single oxygen atom. Heat or reduced pressure will produce this change and we have the CO_2 formed.

There must be a shift of electrons during a reversible reaction, this shift being brought about by external conditions—decreased pressure and increased temperature. This may be represented in the reversible form as:

$$H_2CO_3 \rightleftharpoons H_2O + CO_2$$

or in the structural form:

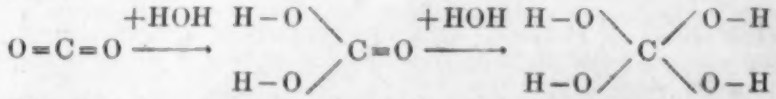


in which the arrows indicate the passage of the electrons. When the pressure is reduced or the temperature raised, or both, evidently the shift of electrons must be as indicated on the right of the equation. A reverse of these conditions will produce the shift indicated on the left of the equation. In conclusion we may say that any reaction may be reversible where the shift of electrons from one atom in the compound to another atom in the compound, may be brought about by changed conditions.

Theoretically if a lowered temperature and an increased pressure causes

$$H_2O + CO_2 \longrightarrow H_2CO_3$$

then a still greater lowering of temperature and increase of pressure ought to result in the addition of another molecule of water to the H_2CO_3, the completed reaction being as indicated below.



This compound may exist in small quantities under the conditions named. Attempts to isolate would be accompanied by even greater difficulties than those encountered in all hitherto unsuccessful attempts to isolate H_2CO_3.

The foregoing is an outline of a method developed by the writer to simplify the teaching of the writing of equations representing chemical reactions. It has simplified and standardized and rendered the teaching of equations more mathematical. It leaves less to chance than the old method and eliminates much of the abstract material of the old method which makes the matter so difficult for the high school student. Apparently it has solved a portion of the many difficulties encountered in the teaching of equations under the old method.

THE EYESIGHT CONSERVATION COUNCIL OF AMERICA.

Election of Secretary James J. Davis of the United States Department of Labor and of Prof. F. C. Caldwell of the Department of Electrical Engineering of Ohio State University as councilors and directors of the Eyesight Conservation Council of America is announced at the national headquarters of the Council in New York City by Guy A. Henry, General Director.

Secretary Davis and Professor Caldwell will participate with other prominent educators, economists, engineers, public officials and civic leaders in the Council's nation-wide activity in behalf of conservation of vision in education and industry. Disclosures made by the Hoover Committee on the Elimination of Waste in Industry showed that poor eyesight among the workers was causing heavy annual economic losses. Surveys in numerous cities have revealed similar conditions of vision in the schools.

To remedy this situation is a national duty, Secretary Davis declares in a statement made public by the Council.

"In my earlier life, as a workman, and in the course of my duties as Secretary of Labor," he says, "I have come to know something of this problem, particularly in its relation to men and women in industry. It is a problem in human service which in its solution will mean much to the whole service of America in life, economic prosperity and happiness.

"Sight is, paradoxically enough, the most highly prized and at the same time the most abused of the human senses. I am informed that of the 40,000,000 or more men and women who are gainfully employed in the United States, upwards of 25,000,000 suffer from some form of defective vision which is capable of correction and which should be corrected. This is an astounding number, and its reduction to a minimum would plainly better the condition of these sufferers, increase their efficiency in industry, and generally benefit the nation.

"Many of those so afflicted owe their defects to the conditions under which they are employed. I, myself, know something of the evils which come in the train of watching molten metal through the peep-hole of a puddling furnace. Whatever can be done in the way of improving employment conditions in this respect will be of inestimable service to the man who labors.

"I am in deep sympathy with eye conservation work among children. Here I march with you. I am convinced that mankind owes no higher duty to society and to God than service to childhood, and that whatever we may be able to do to aid the citizens of the future will earn a great reward."

THE EVOLUTION OF OUR EXPONENTIAL NOTATION

By Florin Cajori,
University of California.

There prevails an erroneous impression that when Descartes in 1637 invented our exponential notation in algebra for positive integral exponents, he hit upon this happy symbolism without receiving direct suggestions from predecessors. As a matter of fact, there is no advancement *per saltum* in this notation; there is a close continuity, which discloses itself in the writings of Chuquet, Bombelli, Digges, Cataldi, Steven, Romanus Bürgi, Reymers, Hérigone, Hume, and Descartes. In its early stages the development was delayed by the wide adoption of inferior notations which were introduced by Rudolff, Stifel, Vieta and others.

Notations applied only to an unknown quantity, the base being omitted. As early as the fourteenth century, Oresme had the exponential concept, but his notation stands in historical isolation and does not constitute a part of the course of evolution of our modern exponential symbolism.

The earliest important step toward the modern notation was taken by Nicolas Chuquet, a physician at Lyons in France, in his *Le triparty en la science des nombres*[1], 1484. Though before 1880 existent only in manuscript, it was known to one, possibly more, French writers of the beginning of the sixteenth century. Hence it was not without influence in the progress of algebra. Chuquet wrote 12^0, 12^1, 12^2, 12^3 to designate, respectively, our 12, 12x, $12x^2$, $12x^3$. From this it appears that with him 12^2 does not mean 12×12, but our $12x^2$; the exponent is written without its base. He writes even $.12.^{1.\bar{m}}$, which means $12x^{-1}$. His "adiouster $8.^1$ avec $\bar{m}.5.^1$ monte tout $.3.^1$" means our $8x - 5x = 3x$. He gives 12° times 12° as equal to 144°; i. e., $12x^\circ \cdot 12x^\circ = 144x^\circ$.

A similar symbolism is found in an algebra of the Italian, Rafael Bombelli, printed in 1572 and 1579 at Bologna. He lets the exponent rest in a circular arc placed above the coefficient. Thus[2], "24. m. 20 Equale à 4. p. 20 p. 16." means $24 - 20x = 4x^2 + 20x + 16$. Bombelli's notation became known to the Belgian, Simon Stevin, who modified it in 1585 and in later publica-

[1] Printed in Boncompagni's *Bulletin*, Vol. 13, 1880, p. 555-659, 693-814; Vol. 14, p. 413-460. See Vol. 13, p. 739.

[2] Rafael Bombelli, *L'algebra opera*, Bologna, 1579, p. 251.

tion by using the full circle in place of the cup-like arc. Stevin's notation is well known and was used by him also for decimal fractions. In decimal fractions the exponents must be interpreted as powers of the unexpressed base one-tenth; in algebra the exponents indicated powers of a suppressed base x.

Meanwhile a notation involving the same idea was evolved in England by Leonard and Thomas Digges, father and son, in a curious text, the *Stratioticos* (1579), which, as the name indicates, was intended for soldiers. The successive powers of the unknown are represented by writing the numerals 1, 2, 3, 4, 5, 6, 7, 8, 9 in a recumbent position and further distinguishing them from ordinary numeral forms by drawing a line across them. These recumbent and crossed-out numerals could be easily distinguished from the ordinary numerals. Nevertheless, as far as we have observed, the Digges signs were not adopted by succeeding writers. Hitherto they have failed to draw the attention even of historians of mathematics. However, a very similar symbolism was contrived by Pietro Antonio Cataldi of Bologna, in an algebra of 1610 and a book on roots of 1613. Probably he got his idea from Bombelli, his predecessor at Bologna. Cataldi omitted Bombelli's circular arcs, crossed the digits instead, and, unlike Digges, wrote the numeral exponents in their natural upright position.[3] His 53 *via* 84 fà 407 means $5x^3.8x^4 = 40x^7$. His sign for x is 1.

The drawback of Stevin's symbolism lay in the difficulty of writing and printing numerals and fractions inside of the circle. Apparently as a relief from this cumbrousness, we find that the Dutch writer, Adrianus Romanus, in his *Ideae Mathematicae pars prima*, Antwerp, 1593, uses in place of the complete circle two rounded parentheses and vinculums above and below; thus with him $1(\overline{\underline{45}})$ stands for x^{45}. He uses this notation in writing his famous equation of the 45th degree. However, the circle, apparently, made stronger appeal to the esthetic sense of some writers, and so we find that Albert Girard in his *Invention nouvelle en L'Algebre*, Amsterdam, 1629, retains the circle, as does also Franciscus van Schooten[4] in his early publications and when he quotes from Girard.

A notation more in line with Chuquet's was that of the Swiss Joost Bürgi who, in a manuscript now kept in the library of the

[3] G. Wertheim, *Zeitschr. f. Math. u. Physik*, Vol. 44, 1899, Hist. Lit. Abteliung, p. 48.

[4] Francisci à Schooten *De Organica conicarum sectionum—Tractatus*, Leyden, 1646, p. 96; Schooten's *Renati Descartes Geometria*, Frankfurt a/M, 1695, p. 359.

observatory at Pulkowa, used Roman numerals for exponents and wrote[5] vi v iv iii ii i o

$$8 + 12 - 9 + 10 + 3 + 7 - 4$$

for $8x^5+12x^5-9x^4+10x^3+3x^2+7x-4$

In this notation Bürgi was followed by Nicolaus Reymers (1601) and J. Kepler.

Notations applied to any quantity, the base being designated. As long as literal coefficients were not used and numbers were not generally represented by letters, the notations of Chuquet, Bombelli, Stevin, Digges, Cataldi, and others were quite adequate. There was no pressing need of indicating the powers of a given number, say the cube of twelve; they could be computed at once. Moreover, as only the unknown quantity was raised to powers which could not be computed on the spot, why should one go to the trouble of writing down the base? Was it not sufficient to put down the exponent and omit the base? Was it not easier to write $\overset{i\,i}{16}$ than $16x^2$? But when through the innovations of Vieta and others, literal coefficients came to be used, and when several unknowns or variables came to be used, as in analytic geometry, then the omission of the base becomes a serious defect in the symbolism. It will not do to write $15x^2-16y^2$ as $\overset{i\,i}{15}-\overset{i\,i}{16}$. In watching the coming changes in notation, the reader will bear this problem in mind.

The earliest important step was taken by two mathematicians whom we have already named Albert Girard and Adr. Romanus. Girard in 1629 suggested the plan of attaching to an exponent placed within a circle two different meanings according to its location. If placed *before* a number, it meant the power of that number; if placed *after*, it meant a power of x having that number as coefficient. Accordingly, [6] 18 meant the same as 18 and as 18 ⓪; 18 ② meant $18x^2$; 3/2 49 stood for $49^{3/2}$. Romanus 1 uses letters and writes the bases as well as the exponents in expressions like

A(4)+B(4)+4A(3)*in*B+6A(2)*in*(B2)+4A*in*B(3) which signifies $A^4+B^4+4A^3B+6A^2B^2+4AB^3$.

A similar suggestion came from the Frenchman, Pierre Hérigone, a mathematician who had a passion for new notations. His *Cursus Mathematicus*, Paris, 1634 (second edition 1644),

[5] P. Treutlein in *Abhandlungen zur Geschichte der Mathematik*, Vol. 2, Leipzig, 1879, p. 36, 104.
[6] See H. Bosmans in *Ann. Soc. sc. de Bruxelles 30, 2. partie*, 1906, p.

in six volumes, is a curiosity shop for strange new symbolisms. For example, *equality* is expressed by 2/2, *greater than* by 3/2. His exponential symbolism involves both base and exponent, the exponent being placed after the base and on the same level with it. Thus he wrote a^3 as *a3*, $2b^4$ as *2b4*, $2ba^2$ as *2ba2*. The coefficient was placed *before* the letter, the exponent *after*.

Hardly as advanced was the symbolism used by James Hume in his *Traité de l'algebre*, Paris, 1635. Hume was a Scotsman who resided in Paris and was the author of several mathematical books written in Latin and French. Like Bürgi, he writes the exponents in Roman numerals, but in 1635 does not write down the base. "Comme[7] 9ij+6j s'exprime 9 quarres, plus six racines, que fait 48 si la racine est 2: car 9ij valent 36, et 6j valent 12." He gives the polynomial 9iv+4iij−3j+10 and adds together such polynomials "when they are of the same denomination or logarithm."

The year following, Hume[8] brought out an edition of the algebra of Vieta, in which he introduced a much superior notation, writing down the base and elevating the exponent to a position above the regular line and a little to the right. The exponent was expressed as before in Roman numerals. Thus, he wrote A^{iii} for A^3. Except for the use of the Roman numerals, one has here our modern notation. Thus, this Scotsman, residing in Paris, had almost hit upon the exponential symbolism which has become universal through the writings of Descartes.

Descartes' Notation of 1637. Thus far had the notation advanced, before Descartes published his *Géométrie*, 1637. Hérigon and Hume almost hit upon the scheme of Descartes. The only difference was in one case, the position of the exponent, and in the other, the exponent written in Roman signs. Descartes expressed the exponent in Arabic numerals and assigned it an elevated position. Where Hume would write $5a^{iv}$ and Hérigone would write 5a4, Descartes wrote $5a^4$. From the standpoint of the printer, Herigoné's notation was the simpler. But Descartes' elevated exponent offered certain advantages in interpretation which the judgment of subsequent centuries has sustained. Descartes used positive integral exponents only.

Did Stampioen arrive at Descartes' notation independently? Was Descartes alone in adopting the notation $5a^4$ or did others

[7] J. Hume, *Traitè de l'algebre*, 1635, p. 4, 5.
[8] *L'Algèbre de Viète, d'une methode nouvelle claire et facile*, Paris, 1636. See *Oeuvres de Descartes*, ed. Charles Adam et P. Tannery, Vol. 5, p. 504, 506-512.

hit upon this particular form independently? In 1639 this special form was suggested by a young Dutch writer, Johan Stampioen[9]. He makes no acknowledgment of indebtedness to Descartes. He displays independence by introducing = for equality (being perhaps the first writer on the European continent to use this sign), also the form A,,B = C,,D for geometric proportion, and other unusual devices. As regards the exponential notatia, he makes it appear that he had been considering the two forms ^3a and a^3, and had found the latter preferable.[10] Evidently, the symbolism a^3 and the = were adopted by Stampioen after the book had been written; in the body of his book[11] one finds *aaa*, *bbbb*, *jjjjj*, *gggggg*, but the exponential notation above noted, as described in his passage following the Preface, is not used. The = occurs in some places[12], (for instance, on page 47, 62), but usually the word "ghelyck" is employed for equality. In writing equations he, in 1639, encloses the numerals indicating the powers of the unknown in circles as Stevin had done. But Stampioen uses the sign = and the notation a^4 in some but not all parts of a controversial publication of 1640, on the solution of cubic equations and directed against Waessenaer, a personal friend of Descartes. In view of the fact that Stampioen does not state the originators of any of the notations which he uses, it is not improbable that his a^3 was taken from Descartes, even though Stempioen stands out as an opponent of Descartes.[13]

Descartes preferred the notation aa to a^2. Franciscus van Schooten[14] of Holland, in 1646, followed Descartes even in writing qq, xx rather than q^2, x^2, but in his 1649 Latin edition of Descartes' geometry he wrote preferably x^2. The symbolism xx was used not only by Descartes, but also by Huygens, Rahn, Kersey, Wallis, Newton, Halley, Rolle, Euler—in fact, by most writers of the second half of the seventeenth and of the eighteenth centuries. Later, Gauss[15] was in the habit of writing xx and he defended his practice by the statement that x^2 did not take up

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[9] *Algebra ofte Nieuwe Stel-Regel*, door Johan Stempioen d'Jonghe, The Hague, 1639. See his statement following the Preface.

[10] Stampioen's own words are: "aaa. dit is a drievondich in hem selfs gemennichvuldicht. men soude oock daer voor Konnen stellen ^3a ofte beter a^3."

[11] J. Stampioen, *op. cit.*, p. 343, 344, 348.

[12] *I. I. Stampioenii Wisk-Konstigh ende Reden-Maetigh Bewijs*. 's Graven-Hage, 1640, unpaged introduction and p. 52-55.

[13] See *Oeuvres de. Descartes*, Vol. 12, 1910, p. 32, 272-274.

[14] *Francisci à Schooten Leydensis de Organica conicarum sectionum—Tractatus*, Leyden, 1646, p. 91 ff.

[15] M. Cantor, *op. cit.*, Vol. 2, 2 Ed., p. 794 Note.

less space than xx, hence did not fulfill the main object of a symbol. The x^2 was preferred by Leibniz, Ozanam, David Gregory, and Pascal.

In England John Wallis[16] was one of the earliest writers to use Descartes' exponential symbolism. He used it in 1655, even though he had himself been trained in Oughtred's notation. The Cartesian notation is found in the algebraic parts of Isaac Barrow's[17] geometric lectures of 1670 and in John Kersey's algebra[18] of 1673. The adoption of Descartes' a^4 in strictly algebraic operations and the retention of the older A_q, A_c, for A^2, A^3, in geometric analysis is of frequent occurrence, not only in Barrow, but also in Whiston's edition of Tacquet's *Euclid*[19]. In the Philosphical Transactions of London none of the Pre-Cartesian Notations for powers appear, except a few times in an article of 1714 from the pen of John Cotes, and an occasional tendency to adhere to the primitive, but very lucid method of repeating the factors as *aaa* for a^3. The modern exponents did not appear in any of the numerous editions of William Oughtred's *Clavis mathematicae*; the last edition of that popular book appeared in 1694 and received a new impression in 1702. On February 5, 1666-7, John Wallis [20] wrote to John Collins, when a proposed new edition of Oughtred's *Clavis* was under discussion. "It is true, that as in other things so in mathematics, fashions will daily alter, and that which Mr. Oughtred designed by great letters may now by others be designed by small; but a mathematician will, with the same ease and advantage, understand A_c or *aaa*." John Pell wrote s^2 and t^2 in a letter written in Amsterdam on August 7, 1645[21]. J. H. Rahn's *Teutsche Algebra*, printed in 1659 in Zurich, contains for positive integral powers two notations, one using the Cartesian exponents, a^3, x^4, the other consisting of writing the Greek letters $^{\theta}$ between the base and the exponent on the right. Thus a $^{\theta}3$ signifies a^3. This Greek symbol is used to signify *involution*, a process which Rahn calls *involviren*. In English translation, altered and augmented by John Pell, was made by Thomas Brancker and published in 1668 in London. In the same year positive integral

[16]John Wallis, *Arithmetica Infinitorum*, Oxford, 1655, p. 16 ff.
[17]Isaac Barrow, *Lectiones Geometriae*, London, 1670, Lecture XIII. (W. Whewell's Ed.), p. 309.
[18]John Kersey, *Algebra*, London, 1673, p. 11.
[19]See, for instance, *Elementa Euclidea geometriae auctore Andrea Tacquet, . . . Gulielmus Whiston*, Amsterdam, 1725, p. 41.
[20]Rigaud, *Correspondence of Scientific Men f the Seventeenth Century*, Vol. 1, Oxford, 1841, p. 63.
[21]J. O. Halliwell, *Progress of Science in England*, London, 1841, p. 89.

exponents were used by Lord Brouncker[22] in the Philosophical Transactions.

Of interest is the following passage in Newton's *Universal Arithmetick*[23], which consists of lectures delivered by him at Cambridge in the period 1669-1685 and first printed in 1707. "Thus $\sqrt{64}$ denotes 8; and $\sqrt{3:64}$ denotes 4 . . . . . There are some, that to denote the Square of the first Power, make use of q, and of c for the Cube, qq for the Biquadrate, and qc for the Quadrato-Cube, etc. . . . . Others make use of other sorts of Notes, but they are now almost out of Fashion."

In France the Cartesian exponential notation was not adopted as early as one might have expected. In Jacobo de Billy's *Nova geometriae clavis*, Paris, 1643, there is no trace of that notation; the equation $x + x^2 = 20$ is written 1 R + 1 Q aeguatur 20. In Fermat's edition[24] of Diophantus of 1670 one reads in the introduction 1 Q Q + 4 C + 10 Q + 20 N + 1
for $x^4 + 4x^3 + 10x^2 + 20x + 1$.

But in an edition of the works of Fermat brought out in 1679, after his death, the algebraic notation of Vieta which he had followed, was discarded in favor of the exponents of Descartes[25]. Pascal[26] made free use of positive integral exponents in several of his papers, particularly the *Potestatum numericarum summa*, 1654.

In Italy Caroli Renaldini [27] in 1665 uses both old and new exponential notations, with the latter predominating.

Negative, fractional and literal exponents.—Negative and fractional exponential notations had been suggested by Oresme, Chuquet, Stevin, and others, but the modern symbolism for these is due to Wallis and Newton. Wallis[28] in 1656 used positive integral exponents and speaks of negative and fractional "indices." But he does not actually write a^{-1} for $1/a$, $a^{\frac{3}{2}}$ for Ma^3. He speaks of the series $1/\sqrt{1}, 1/\sqrt{2}, 1/\sqrt{3}$, etc., as having the "index $-\frac{1}{2}$;" of the series 1, 4, 9, ... as having the "index 2." Our modern notation involving fractional and negative exponents was formally introduced a dozen years later by Newton[29] in a letter of June 13, 1676, to Oldenburg.

[22] *Phil. Trans.*, Vol. III; for anno 1668, printed 1669, London, p. 647.
[23] Newton's *Universal Arithmetick*, London, 1728, p. 7.
[24] *Diophanti Alexandrini arithmeticorum libri Lex, cum commentariis G. B. Bacheti V. C. et observationibus D. P. de Fermat.* Tolosae, 1670, p. 27.
[25] See *Oeuvres de Fermat* ed. Paul Tannery et Charles Henry, T. 1, Paris, 1891, p. 91, foot-note.
[26] *Oeuvres de Pascal*, Ed. Leon Brunschvicg et Pierre Boutroux, Vol. 3, Paris, 1908, pp. 349-358.
[27] Caroli Renaldinii, *Ars analytica* . . . Florence, 1665, p. 11, 80, 144.
[28] J. Wallis *Arithmetica infinitorum*, 1656, p. 80. Prop. CVI.
[29] Isaaci Newtoni *Opera* (Ed. S. Horsely), Tom. IV, London, 1782, p. 215.

then Secretary of the Royal Society of London, which explains the use of negative and fractional exponents and exhibits them in his binomial formula first announced in that letter: $\overline{P+PQ}\Big|^{m/n} = P^{m/n} + m/n\ AQ + m-n/2n\ BQ + m-2n/3n\ CQ + m-3n/4n\ DQ + \text{etc.}$, where $A = P^{m/n}$, $B = {}^{m/n}P^{m/n}Q$, etc., and where m/n may represent any real and national number. It should be observed also that Newton used here *literal* exponents such as had been used a few times by Wallis[30], in 1657, in expressions like $\sqrt[d]{R^d} = R$, $AR^m \times AR^n = A^2R^{m+n}$, which arose in the treatment of geometric progression. Wallis gives also the division $AR^m) AR^{m+n} + (R^n$.

The theory of exponents involving integral, fractional or negative indices was explained in 1708 in a popular work on the calculus by Charles Reyneau[31], because, as the author explains, this theory is not explained in works on algebra.

Of interest is the following quotation from a discussion by T. P. Nunn, in the *Mathematical Gazette*, Vol. VI, 1912, p. 255. "Those who are acquainted with the work of John Wallis will remember that he invented negative and fractional indices in the course of an investigation into methods of evaluating areas, etc. He had discovered that if the ordinates of a curve follow the law $y = kx^n$, its area follows the law $A = 1/n+1 \cdot kx^{n+1}$, n being (necessarily) a positive integer. This law is so remarkably simple and so powerful as a method that Wallis was prompted to inquire whether cases in which the ordinates follow such laws as $y = k/x^n$, $y = k\sqrt[n]{x}$ could not be brought within its scope. He found that this extension of the law would be possible if k/x^n could be written kx^{-n}, and $k\sqrt[n]{x}$ as $kx^{1/n}$. From this, from numerous other historical instances, and from general psychological observation, I draw the conclusion that extensions of notation should be taught because and when they are needed for the attainment of some practical purpose, and that logical criticism should come *after* the suggestion of an extension to assure us of its validity."

Conclusion.—There is perhaps no symbolism in ordinary algebra which has been as well chosen and is as elastic as the Cartesian exponents. Descartes wrote a^3, x^4; the extension of this to general exponents a^n was easy. Moreover, the introduction of fractional and negative numbers, as exponents, was

[30] J. Wallis, *Mathesis universalis*, Oxford 1657, p. 292, 293, 294.
[31] Charles Reyneau *Analyse demontree*, Vol. 2, Paris, 1708. p. XVII.

readily accomplished. The irrational exponent, as in $a2^{\frac{1}{2}}$, found unchallenged admission. It was natural to try exponents in the form of pure imaginary or of complex numbers (L. Euler, 1740). In the nineteenth century valuable interpretations were found which constitute the general theory of b^n where b and n may both be complex. Our exponential notation has been an aid for the advancement of the science of algebra to a degree that could not have been possible under the old German notation H, ξ, C, $\xi\xi$, ξC, bB, etc., or the other early notations. Nowhere is the importance of a good notation for the rapid advancement of a mathematical science exhibited more forcibly than in the exponential symbolism of algebra.

SOCRATES TEACHES MATHEMATICS

By Norman Anning,

Ann Arbor, Mich.

Socrates. What were we doing yesterday?

E: Played with blocks.

C: Made a cube.

A: Found what pieces make up $(x + y)^3$.

Socrates. Right. Shall we go on?

Chorus (reinforced from behind the scenes). Yes. Sure. Umhuh.

Socrates. Well, what do you see here?

H: Two blocks.

F: Two cubes.

C: One cube on another.

Socrates. Say it with algebra.

A: x^3+y^3.

B: The sum of two cubes.

Socrates. Why is it x^3+y^3?

D: Well, isn't it the X cube plus the Y cube?

Socrates Why is it x^3+y^3?

A (after a pause during which Socrates, who is pulling hard, runs his finger significantly along the edge of the big cube and begins to write upon the sandboard "$x\times x\times x$") eagerly. Because if we call the edge of one x and of the other y that tells how much wood there is.

Since actual reproduction of the historic Socrates is difficult for even the skilled historian and for the amateur is quite impossible we choose the easier course of introducing into a modern classroom a being who shall bear the name and some of the (reputed) characteristics of the real Socrates.

Socrates (pointing to the blocks): Yes, you may call this the sum of two cubes and this (pointing to the finished x^3+y^3 on the sandboard) is our short way of writing down their total volume, or, as A puts it, a measure of all the wood in them, of all the space they occupy.

E (who has been gazing up through the branches): What's space?

Socrates. Don't you know yet what space is?

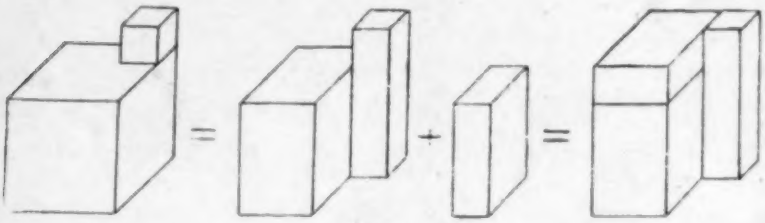


FIG. 1.

Socrates: Now if I cut this piece off and put it up here, is there any change in the volume?

Chorus: No.

H: Yes, the sawdust!

Socrates: Hush. What do you observe?

D: It fits.

B: It's all the same height.

F: It looks like two long blocks.

Socrates: Good. How high is it?

A: $x+y$.

Socrates: Now let's study F's two long blocks. B, take the stylus and write down our results. The small one first.

H: It's square on the end.

C: It is y by y by $(x+y)$.

Socrates: What is its volume?

A: The product of those numbers.

B writes down $(x+y)y^2$.

Socrates (ponders, perhaps on the question "Can a volume be a product?" but says nothing and the quest goes on). Now the larger block.

C: Well, it is $(x+y)$ high.

E: And it's x this way.

Socrates: Go on. How thick is it?

A: $(x-y)$.

B, instructed by the class, writes down $(x+y)x(x-y)$.

Socrates (turning to the sand-board). Can anyone see a way to improve that?

D: There's an $(x+y)$ in each part.

Socrates takes the stylus and writes $(x+y)$ $(x(x-y)+y^2)$ and finally $(x+y)$ (x^2-xy+y^2).

Socrates: Could the sum of any two cubes be handled similarly?

Class: Yes.

Socrates: And what would we have?

E (*sotto voice*): Another formula to learn.

Socrates: And worth learning because it is a gem of universal truth.

With some assistance they put it into words and, holding up their hands, march around chanting

"x^3+y^3, tra-la-la,
Always has a factor, ha-ha-ha!"

Socrates: What shall we try next?

A: The difference of two cubes.

D: How could you take one cube from another?

B: Get a chisel and gouge it out, you sompey.

H: It would be better to saw it out.

Socrates: Well, practical man, tell us how you would saw it out.

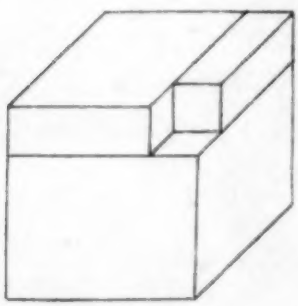
H: First I'd cut off a slab of the right thickness; from that I could cut a piece of the right width and then just saw the cube off the end.

Socrates: Do it.

H gets saw, straight-edge and pencil and goes to work. The other youths pretend to marvel at his "form."

Socrates (seeing an opportunity): Why does he draw lines on two faces of the block?

No answer. H finishes, takes the small cube for his reward and piles the rest as it was.



The boys attack the pile eagerly and, almost unaided, arrive at the final formula.

$(x^3-y^3)=(x-y)x^2+(x-y)xy+(x-y)y^2$.

A: Master, in a tablet of the ancients I find inscribed these symbols. $x^3+y^3+z^3-3xyz$. Could we study them tomorrow?

Socrates: If you will in the mean-

time cut a cube to exhibit $(x+y+z)^3$ we will gladly invoke the aid of the gods and discover what we can.

E: Could you make one cube out of two?

Socrates: I know not; I'll ask Theaetetus.

Socrates, suddenly remembering the parting words of Xantippe, hastens away to the market of the slayer of oxen and the youths remain in silence till he is out of earshot.

B (clapping the largest blocks together): Yea! Sock! but say, fellers, those rope-pullers of the Piraeus havent a snowball's chance to win in the Pan-Attic league.

C: I would burn incense to Zeus. Gimme a match.

Exeunt.

Postscript.

$(x+y+z)^3 = A+2B.$

Where $A=(x+y+z)\ (x^2+y^2+z^2) = x^3+y^3+z^3+\sum x^2+y.$

$B=(x+y+z)\ (yz+zx+xy) = 3xyz+\sum x^2y.$

$A-B = (x+y+z)\ (x^2+y^2+z^2-yz-zx-xy) = x^3+y^3+z^3-3xyz.$

$A+2B=x^3+y^3+z^3+3\sum x^2y+6xyz.$

A good student should have little difficulty in showing that $A=xyz+(y+z)\ (z+x)\ (x+y)$, in finding three, or more, symmetrical ways of exhibiting $(x-y)\ (y-z)\ (z-x)$ and in extending the method to other interesting cubic identities.

PROBLEM DEPARTMENT

Conducted by J. A. Nyberg

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

LATE SOLUTIONS

772. 774. *N. P. Pandya, Mehsana, N. G., India.*

SOLUTIONS OF PROBLEMS

771. *Proposed by L. E. Lunn, Heron Lake, Minnesota.*

Find the greatest numerical factor of $x(x^{12}-1)$ for positive integral values of x greater than 1.

Comment by B. F. Yanney, Wooster College, Ohio.

It seems to have been overlooked by the solver of problem 771, in the April number of SCHOOL SCIENCE AND MATHEMATICS, that if x is an odd integer, $x(x^4-1)=x(x-1)\ (x+1)\ (x^2+1)$ is divisible by 240, and hence $x(x^{12}-1)$ is divisible by 21840. The additional factor 2 may be accounted for thus: $(x-1)\ (x+1)$ is divisible by 8, since each factor

is an even integer, one or the other being divisible by 4. This latter fact is evident for the reason that of two consecutive even integers one or the other is always divisible by 4. Furthermore, the factor x^2+1 is also divisible by 2.

It may be of interest to note also that when x is an odd integer other than 3, $x(x^{12}-1)$ is divisible by 65520, the additional factor 3 arising in the factor x^8+x^4+1. For every odd integer other than 3 is of the type $3k\pm1$. This substituted in x^8+x^4+1 gives an expression of the form $3A+3$.

781. *Proposed by I. N. Warner, State Normal School, Platteville, Wis.*

Which is more profitable and how much: for a farmer to sell his corn December 1 at 46c per bushel, or on May 1 at 52c per bushel, money being worth six per cent, and using the following table of shrinkage for ear corn from its harvesting to the first of each succeeding month:

Nov. 5.2%	Dec. 6.9%	Jan. 7.5%	Feb. 7.8%
Mar. 9.7%	Apr. 12.8%	May 14.7%	

(From *Thomas, Rural Arithmetic*, page 197, ex. 31)

Solution by Thomas E. N. Eaton, Redlands H. S., Cal.

Let x = number of bushels of corn at harvest. Then

$.931x$ = number of bushels of corn on Dec. 1.

$.931x(46)$ = value of corn on Dec. 1.

$.931x(46)\ (1.025)$ = value of this corn on Dec. 1, when we allow 6% interest on the returns from the harvest. This equals \$.438966.

$.853x$ = number of bushels of corn on May 1.

$.853x(52)$ = value of this corn on May 1, or \$.443560.

By waiting to sell till May 1 the profit is \$.0045934 per bushel, which is about 1% better than on Dec. 1. (On the other hand, is it worth one percent when we consider insurance on the crop and worry?)

Also solved by *Ellsworth Billig and Wadsworth E. Pohl*, pupils of the *Redlands High School, California.*

782. *Proposed by C. E. Githens, Wheeling, W. Va.*

Find at least four of the smallest rational values of the unknowns in $x^4-6y^2=1$.

Solution by James A. Bell, Humeston, Iowa.

Let $x=(6a^2+1)\ /\ (6a^2-1)$. Then $y=2a\ /\ (6a^2-1)$. And any rational value substituted for a gives rational values for x and y.

Solution by the Proposer.

If we write $\sqrt{6}$ as a continued fraction

$$\sqrt{6}=2+\cfrac{1}{+2+\cfrac{1}{+4+\cfrac{1}{+2+\cfrac{1}{+4+\cfrac{1}{+2+\text{etc.}}}}}}$$

then the successive values are $5/2$, $22/9$, $49/20$, $218/89$, $458/192$, $2158/881$, $4801/1960$, etc. And from the first third, fifth, seventh values of $\sqrt{6}$ we pick the integral values $x=5$, $y=2$; $x=49$, $y=20$; $x=485$, $y=198$; $x=4801$, $y=1960$.

This problem is known historically as "Pell's Problem" although Fermat first proposed it in the form $ax^2+1=y^2$. We might add, on the side, that John Pell is credited with introducing into England in 1668 the sign $\div$ for division.

783. *Proposed by Burrell Morgan, Krollitz, W. Va.*

The base of an isosceles trapezoid is 22 rods, the other three sides are all equal, and each diagonal is 25 rods. Find the lengths of the sides of the trapezoid, and derive a formula for the sides, s, when the base is b and the diagonals d.

Solution by Arria Murto, Ruskin High School, Hickman Mills, Missouri.

$EB=\frac{1}{2}(b-s)$. $AE=\frac{1}{2}(b+s)$. $CE^2=s^2-\frac{1}{4}(b-s)^2$.

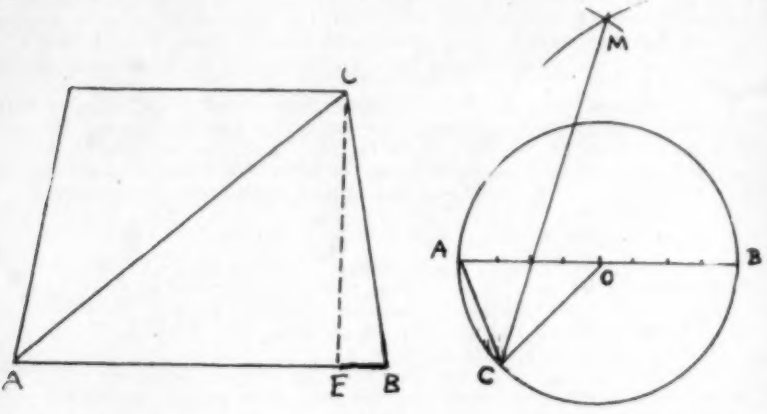
Hence $d^2=\frac{1}{4}(b+s)^2+s^2-\frac{1}{4}(b-s)^2$.

Then $s=\frac{1}{2}(-b\pm\sqrt{b^2+4d^2})$.

For the special case when $d=25$, $b=22$, we get $s=16.31+$.

Also solved by *Thomas E. N. Eaton; C. E. Githens; Lucille A. Mower, Indianapolis, Ind.; and Junior Meserve, Wadsworth E. Pohl, Redlands.* *C. E. Githens* calls attention to the fact that $d=24$, $b=20$, $s=16$, and other numbers proportional to these, are integral solutions of the above equation in d, b, s, and asks: Are there other values in a different proportion?

Since the quadrilateral is an isosceles trapezoid, we may apply Ptolemy's Theorem: The product of the diagonals equals the sum of the products of the opposite sides. Hence $d^2 = s^2 + bs$. From this equation the formula for s can be directly obtained.



784. *Proposed by Ben Shaw, Salida, Colo.*

Is the following construction for finding the side of an inscribed polygon of n sides accurate or approximate?

Divide a diameter AB into n equal parts. With A and B as centers and AB for a radius draw two arcs intersecting at M. Draw a line from M through the second (from A) division point of AB and extend it to intersect the circle again at C. Then AC is a side of the desired polygon.

A complete solution of this problem by *H. F. MacNeish, College of the City of New York* appeared in June, 1916, of SCHOOL SCIENCE AND MATHEMATICS, and in the American Mathematical Monthly, 1903, page 207. By computing the size of $\angle AOC$ the error in the construction can be determined. For $n = 3$, 4, and 6 the construction is correct. For other values of n, there is an error which varies irregularly as is seen from the following table.

n	Error	n	Error	n	Error	n	Error
5	2′ 48″	9	16′ 38″	24	38′	90	1° 14′ 30″
7	5′ 40″	10	21′ 18″	48	1° 2′ 20″	180	15′
8	11′ 14″	20	2′ 40″	72	29′	360	7′ 30″

785. *For high school students. Proposed by I. N. Warner, Platteville, Wis.*

In a 100-yard race A beats B by 8 yards, and C by 17 yards. What handicap in yards may B give C in a 100-yard race so as to run him an even finish?

I. *Solution by Ralph Waters, Palmyra, Illinois.*

Let x = number of yds. C can run while B runs 100 yds.

B runs 92 yd. while A runs 100 yd. C runs 83 yd. while A runs 100 yd. and also while B runs 92 yd.

If it can be found how many yards C can run while B runs 100 yd. then the problem is solved. So

$$83 : 92 :: x : 100$$
$$92x = 8300$$
$$x = 90\ 5/23 \text{ yd.}$$

(no. of yd. C can run while B runs 100 yd.) Then

100 yd. − 90 5/23 yd. = 9 18/23 yd. (no. of yd. handicap).

II. *Solution by Ellsworth Billig, Redlands, California.*

B runs 92 yd. while C runs 83 yd. In 92 yd. B beats C by 9 yd. Therefore the rate that B beats C is 9/92.

There are 8 yd. left to run. In the remaining 8 yd. B beats C $9/92 \times 8$ or 18/23.

Therefore B beats C 9 18/23 yd. which he would have to give C as a handicap.

III. *Solution by Warren Oliver Jr., Lewis and Clark High School, Spokane, Wash.*

A/B = 100/92. A/C = 100/83 ∴ C/B = A/B × C/A = 83/92 = 90.21/100

Therefore, while B goes 100 yd., C goes 90.21 yd.

100 yd. − 90.21 yd. = 9.79 yd. the handicap necessary for C to run B an even race. Answer.

IV. *Solution by Wadsworth E. Pohl, '24, Redlands, California.*

In going 92 yd. B gains 9 yards on C.

In going 100 yd. B gains x yards on C.

$$92 : 9 :: 100 : x$$

$$900 = 92x$$

$x = 9.782$ yd. that B will gain on C in running 100 yd.

∴ C must have a handicap of 9.782 yd.

Also solved by *Frances Upton Buckmaster, Redlands, Calif.; Elizabeth Hopkins, Ruskin H. S., Hickman Mills, Mo.; Walter Hoover, Palmyra; Ill.; Frank Marshall, Dickinson H. S., Jersey City, N. J.; Neil McMullin, Redlands, Calif.*

The four solutions shown above have not been arranged in the order of merit. The editor leaves the reader to decide for himself which is best. The solutions have this month been printed exactly as received with no contractions by the editor in order that teachers may see how differently pupils think and plan the various steps.

During the past year the editor has selected most of the problems intended for the pupils. Next year he hopes the teachers will submit these problems. Every teacher ought to know some problem which has aroused the pupil's interest.

PROBLEMS FOR SOLUTION.

796. *Proposed by C. E. Githens, Wheeling, W. Va.*

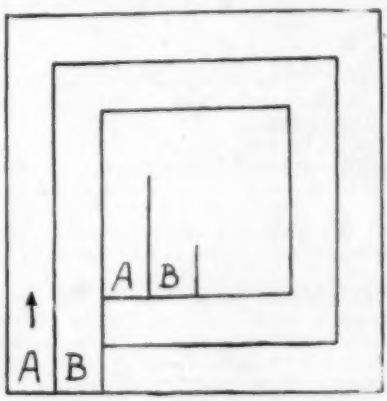
What other integral solutions of $d^2 = s^2 + bs$ exist besides $d = 6a$, $b = 5a$, $s = 4a$?

797. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Find the general expression for the number that 2, 3, 4, 5, and 6 will each divide with a remainder of 1, but 7 will divide with a remainder 0.

798. *Proposed by J. F. Howard, San Antonio, Texas.*

What is the relation between the velocity of a man and the velocity of the end of his shadow, l being the height of the source of light and h being the height of the man.



799. *Proposed by W. C. Eells, Whitman College, Walla Walla, Wash.*

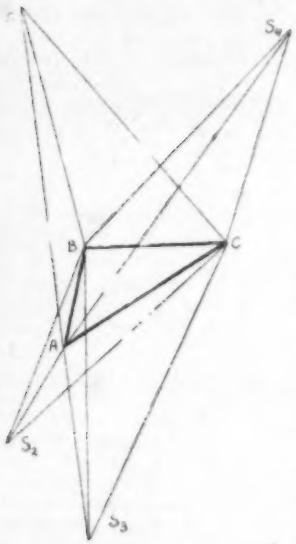
The following problem was sent me by a farmer:

A and B each have 10-foot drills and are seeding a quarter section of land lying in a square. A takes the lead. How much farther does A travel than B? Some here contend that A travels no farther than B. Others claim A travels farther only on the first round and the last round.

To avoid misunderstanding a figure is added showing how A and B move; the width of the path is 10 feet.

800. *For high school pupils. Proposed by John J. Sheekey, St. Joseph's Normal Institute, Ammendale, Md.*

Find the volume of the figure generated by an equilateral triangle with side a when revolved about one of its sides.



THE PROBLEM OF THE SHIP AND THE THREE BUOYS.

Discussion by Daniel Kreth, Wellman, Iowa.

A. B. C. are three buoys. AB = 320, BC = 435, CA = 600. A ship, S, finds that AB subtends an angle of 8° and BC an angle of 26°. How far is the ship from each buoy?

Answer

	Case 1.	Case 2.	Case 3.	Case 4.
SA	1062.1	341.07	594.25	1215.2
SB	767.97	654.28	897.60	931.72
SC	965.72	915.12	992.22	687.77

This problem was first proposed as No. 719 in the problem department, and solutions of some or all of the four cases were received from *Moe Buchman, College of the City of New York; Michael Goldberg, Philadelphia, Pa.; J. F. Howard, San Antonio, Texas; Karl Paul, Waubun School, Minnesota; E. Tabor, Upper Lake, Calif.; and the writer.* The editor of the problem department then requested the writer to check the solutions and abbreviate them for publication.

I. *Solution by Michael Goldberg.*

The four cases correspond to the four possible positions of the boat. Let $\angle D = \angle SBC$ in each case, and $x = SA$, $y = SB$, $z = SC$. The angles of $\triangle ABC$ are $\angle A = 44° 39.1'$, $\angle B = 104° 13.1'$, $\angle C = 31° 7.8'$. Of these angles only $\angle B$ will be needed.

Case 1. $y/\sin(D+26) = 435/\sin 26$; $y/\sin(8-B-D) = 320/\sin 8$. Then $\sin(8+B+D) = [435\sin 8/320 \sin 26] \sin(D+26)$ which can be written as $\sin[8-B+26-(D+26)] = k \sin(D+26)$ where $k = 435 \sin 8/320 \sin 26 = .43158$.

The equation above is of the type $\sin(r-s) = k \sin s$ whose solution is $\tan s = \sin r/(\cos r + k)$. [See Problem 778]. In this case $r = 8+26-B$, $s = D+26$. The solution is $\angle D = 103° 17.6'$. Then

$x = 320 \sin(-B-D)/\sin 8 = 1062.1$

$y = 435 \sin(D+26)/\sin 26 = 767.97$

$z = 435 \sin D/\sin 26 = 965.72$

Case 2. $y/\sin(D+26) = 435/\sin 26$; $y/\sin(8-B+D) = 320/\sin 8$ or $\sin[D+26-(B-8+26)] = k \sin(D+26)$. This equation is of the type $\sin(s-r) = k \sin s$ whose solution is $\tan s = \sin r/(\cos r - k)$. Solving gives $\angle D = 112° 45'$; the values of x, y, z follow easily.

Case 3. $y/\sin(D+26) = 435/\sin 26$; $y/\sin(B-D+8) = 320/\sin 8$ or $\sin[B+8+26-(D+26)] = k \sin(D+26)$ which is an equation of the same type as in case 1. $\angle D = 89° 14.4'$, and x, y, z are determined from this.

Case 4. $y/\sin(D+26) = 435/\sin 26$; $y/\sin(8+B+D) = 320/\sin 8$ or $\sin[(D+26)-(26-8-B)] = k \sin(D+26)$, an equation of the same type as in Case 2. $\angle D = 43° 52.5'$.

An examination of the case shows certain peculiarities. The first equation in y is the same in all four cases. Case 3 can be obtained from Case 1 by replacing $-B$ by $+B$, and case 4 from case 2 by replacing B by $-B$. These changes also arise in the formulas for x, y and z (not shown above). Hence it would not be difficult to write formulas for a general solution using angles α, β in place 26° and 8°. The angle r has successively the values $\alpha+\beta-B$, $\alpha-\beta-B$, $\alpha+\beta+B$, $\alpha+\beta-B$.

II. *Solution by E. Tabor.*

(Continued on page 590)

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THE PROBLEM OF THE SHIP AND THE THREE BUOYS

(Continued from page 588)

E. Tabor based his solutions on the methods which are used in constructing the figure. Thus when $\triangle ABC$ is given we find the point S by drawing on the sides AB, BC, CA segments of circles containing the given angles 8° and 26°. The possible positions of the ship are then found as the intersection points of the various circles. Hence the numerical work is based on finding the lengths of the four common chords of these four circles. From the chords the values of x, y, z can then be found. This method avoids the solving of a trigonometric equation but involves the use of more triangles.

III. The writer's method of attack shows a third variation and derives general solutions for x, y, z. Call

$\angle SCB + \angle SAB = 2m$. (Then $2m = B - \alpha - \beta$). and

$\angle SCB - \angle SAB = 2n$.

Then $\angle SCB = m + n$ and $\angle SAB = m - n$.

If now to the point B and the $\triangle ACS$ we apply the theorem: If lines be drawn from a point to the vertices of a polygon, the continued product of the lines of the alternate angles made by the sides of the polygon and the lines so drawn will be equal, we get

$\sin A \sin \beta \sin (m+n) = \sin C \sin \alpha \sin (m-n)$, or

$\sin A \sin \beta / \sin C \sin \alpha = \sin (m-n) / \sin (m+n)$

$= (\tan m - \tan n) / (\tan m + \tan n)$.

Set these fractions equal to h, a known quantity since it can be found from the first fraction. Then from the relation $h = (\tan m - \tan n) / (\tan m + \tan n)$ we can find n. m is already known for $2m = B - \alpha - \beta$ The following values of x, y, z can then be derived.

$x = AB \sin (m - n + \beta) / \sin \beta$; $y = BC \sin (m+n) / \sin \alpha$; $z = BC \sin (m + n + \alpha) / \sin \alpha$.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for April; Brooklyn Botanic Garden; $6.00 *per year*, 75 *cents a copy* "Pectinase in the Spores of Rhizopus," J. L. Weimer and L. L. Harter; "The Chromosomes of Riccardia Pinguis," Amos M. Showalter; "Australasian Botanical Notes II. Victoria, South Australia, and West Australia," Douglas H. Campbell; "Evolution and Geographical Distribution of the Genus Vernonia in North America," Henry Allan Gleason; "The Availability of Iron in Nutrient Solutions for Wheat," W. E. Tottingham and E. J. Rankin; "The Effect of the Hydrogen Ion on the Protoplasm of the Root Haiss of Wheat," Ruth M. Addoms.

American Mathematical Monthly, for November-December; Lancaster, Pa., $5.00 *per year*, 60 *cents a copy*. "Rates of Exchange," H. E. Bray; "A Simple Theory of Competition," G. C. Evans; "On Kellogg's Diophantine Problem," D. R. Curtiss; "A Model for the Peano Surface," A. Emch; "The First Attempt at a Table of Integrals," N. R. Bryan; "Among my Autographs: 29. Legendre and Cauchy Sponsor Abel," D. E. Smith; "Questions and Discussions: 'Uncle Zadock's Rule for Obtaining the Dominical Letter for Any Year'," by Dr. W. H. Vail; "Construction of the Rebular Undecagon by a Sextic Curve," C. B. Haldeman.

Education, for March; *Boston, Mass.* $4.00 *per year*, 40 *cents a copy:* "A Philosophy of Moral Education for Students and Parents," Carroll D. Champlin; "Teaching Mathematics in High Schools," Robert R. Goff; "The American Indian; His Progress and His Needs," Louise Barnes La Bella; "British Education Act of 1918," P. H. Pearson; "Athletics As an Aid to School Morale," T. C. Hart.

Journal of Geography, for April; *2249 Calumet Ave., Chicago*, $2.00 *per year*, 25 *cents a copy:* "Recent Development in Geography Testing," P. R. Stevenson; "Porto Rico, Jamaica, and Martinique," Robert S. Platt; "Italy—A Problem for Sixth Grade Foreign Boys," Lura A. Chase; "Two Dozen Causes for the Location of Blast Furnaces and Steel Mills in the United States," O. W. Freeman; "The Electrical Con-

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quest of Our Western Mountains," C. E. Cooper; "A Cattle Ranch in New Mexico," L. G. Kennamer.

Nature-Study Review, for March; *Ithaca, N. Y.* $1.50 *per year*, 15 *cents a copy:* "Nature-Study Then and Now," A. C. Boyden; "Personal Reminiscences of Agassiz," I. H. Blake; "Projects in the Princeton Schools," A. T. Washburn; "Wild Flowers as Ornamentals," E. M. Newton; "Nature Notes from Truro;" "Bird Banding as a Winter Sport," J. W. Aldrich; "The Deer-Mouse," F. White.

Photo-Era Magazine, for March; *Boston, Mass. $2.50 per year, 25 cents a copy:* "Toronto," M. O. Hammond; "The Work of Hamilton Revelle," Herbert B. Turner; "'Photoing' Through College," C. Phil Barber; "A New Way to Copy Black-and-White Drawings," Noel Deisch; "The Lame Crow," Wilfred A. French, Ph. D.; "The Beauty of a New England Winter," Edward Elwell Whiting; "The Renovation of Daguerreotypes," The British Journal; "Simple Rules to Make Good Copies," Studio Light; "A Photographer in Bermuda," Livingston Stebbins.

Popular Astronomy, for April; *Northfield, Minn.* $4.00 *per year*: "Report on Mars, No. 25," with Plates XI-XVI, William H. Pickering; "The Diameter of Stars from Radiometric Measures," Harlan T. Stetson; "Twenty-Ninth Meeting of the American Astronomical Society," Concluded; "Report of the Eclipse Committee," "Planetary Occultations in 1923," L. J. Comrie.

School Review, for April; *University of Chicago Press* $2.50 *per year*, 30 *cents a copy:* "Educational News and Editorial Comment," "Curriculum-building in the Rural High School," Emery N. Ferriss; "Increasing Educational Opportunities for High-School Graduates," Grace T. Lewis; "The Improvement of Teaching by Means of 'Home-Made' Non-Standard Diagnostic Tests and Remedial Instruction," Peter L. Spencer; "What to Do with the High-School Assembly," Evan E. Evans; "Public Speaking in the High School," A. H. Horrall; "Comments on Current Educational Practices in Europe," P. H. Pearson; "Training for Power," H. Glicksman.

Scientific Monthly, for April; *Garrison, N. Y.* $5.00 *per year*, 50 *cents a copy:* "The Conservation and Utilization of Natural Resources: The National Problem of Land Reclamation," F. H. Newell; "Problems of Flood Control," Brigadier-General Harry Taylor; "Economic Aspects of Our Timber Supply," Colonel W. B. Greeley; "State Policy in Forestry," William A. L. Bazeley; "The Economic Importance of Wild Life," E. W. Nelson; "The Economic Value of Public Parks and Scenic Preservation," Dr. George F. Kunz; "Economic Aspects of Our National Parks Policy," Robert S. Yard; "Conservation of the Quality of the Rural Population," President Kenyon L. Butterfield; "The Conservation of Health," Dr. Eugene R. Kelley; "Conservation of America's Economic Independence," Dr. Frederick L. Hoffman; "On the History of Physiology and Some of Its Lessons," Professor Yandell Henderson; "The Strength of the Chimpanzee and Orang," John E. Bauman.

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PROBLEMS AND QUESTIONS FOR SOLUTION

The *Editor* would like to hear from others concerning Mutt and Jeff's ideas on physics. Does silence give consent? Which way? See the pictures in SCHOOL SCIENCE AND MATHEMATICS for February, 1923.

Also, what is the answer to Prof. Rigge's question, No. 407, published in April?

It is the close of the year. Have some of your pupils solve questions 408, 409, 410, and 411 from the April issue of SCHOOL SCIENCE AND MATHEMATICS. Scotch and English boys can solve them.

PROBLEM FOR SOLUTION

415. *Proposed by G. Meredith, Jr., West New York (N. J.) High School*

A boy has an electrical device whose resistance is 12 ohms and which requires a current of 2 amperes. The only source of current available is 120 v. D. C. and the only available resistances are two coils of 6 ohms and 16 ohms respectively. Show how these coils can be connected to give just the required current through the device.

[*Letter by Mr. Meredith.* I submit herewith a problem which was recently used by one of our prominent Eastern universities in an entrance examination. Please express your opinion as to whether it is within the range of what we might expect of a high school graduate.]

416. *Proposed by W. R. Spiller, U. of P.*

What is the force with which a ten-pound ball dropped from a height of ten feet will hit the ground?

EXAMINATION PAPERS

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1. Insert the correct word in each blank space: (a) All bases contain the radical ——. (b) —— turn litmus red. (c) Reduction is the —— of ——.

2. Describe an experiment you did in the laboratory to show TWO of these: (a) test for a chloride, (b) preparation and properties of sulphur dioxide, (c) the weight of a liter of oxygen, (d) preparation and properties of NH_3.

3. What chemical idea does each of these suggest? (a) catalytic agent, (b) atomic weight, (c) metal, (d) ore, (e) vapor density.

4. Suppose 18 gm. of water are decomposed. What volume (at 0°C, and 760 mm.) of oxygen is produced?

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5. Designate whether these are right or wrong: (a) Oxygen burns. (b) Salts are produced by neutralization. (c) Nitric oxide is a red gas. (d) Potassium chloride is used in fireworks.

6. How are TWO of these manufactured? (a) Bessemer steel, (b) sodium, (c) potassium nitrate.

7. Complete this equation:

$$CaCl_2 + \text{——} = AgCl + Ca(NO_3)_2.$$

Write the name of each substance under the formula. Write the equation in ionic form.

8. (a) Suggest an experiment to distinguish nitrogen from carbon dioxide. (b) Why is fertilizer put on soil? (c) Why are mantles used on gas lights?

Entrance Examinations, Physics, September, 1922

Answer the following questions:

1. Define the terms "velocity," "acceleration," "energy" and "power." In what units is each of these physical quantities measured in the c. g. s. system?

2. What laws have physicists found to govern a body falling freely under gravity?

3. What is meant by the terms "heat" and "temperature?"

4. What is an electric transformer and what principle governs its operation?

5. What is an electric motor and how does it work?

6. How large will the image be if an object 15 cm. high be placed 5 cm. from a convergent lens of 3 cm. focal length?

7. What is the nature of a light wave and what is meant by the terms "reflection" and "refraction"? Illustrate by sketches.

SOLUTIONS AND ANSWERS

403. *Comment by W. F. Rigge, Creighton University, Omaha, Neb.*

On Jeff's method of weighing the cow. [See pictures in February, 1923, number of SCHOOL SCIENCE AND MATHEMATICS.]

Your Mutt-and-Jeff problem in the February number is very interesting, and likely to cause much discussion. Perhaps the simplest solution would be to use two scales, so that the cow would have its front feet on one and its hind feet on the other. Its weight would then evidently be the sum of the indications. If now the platform of each of the scales in turn is locked so that it becomes a part of terrafirma, the reading of the other will surely remain as before. Therefore, the sum.

399. A motor truck hauls a 43-ton boiler six city blocks.

A 5-ton truck carries a capacity load over an ordinary country road. Which was performing the greater "stunt"?

(a) Adopt reasonable figures for road and load resistances and compare numerically.

(b) What apparatus would an engineer require to make an experimental comparison?

399. *Solution by Ferdinand Jehle, Experimental Engineer, Cleveland, Ohio.*

(a) On a brick or asphalt road the tractive resistance is taken as 40 lb. per ton.

Then tractive resistance $= 43 \times 40 = 1720$ lb.
Tractive resistance of truck $= 5 \times 40 = 200$

Total tractive resistance 1920 lbs. on a level road

Take the average grade as 1-2% $48 \times 2000 \times .005 = 480$ lb. pull to overcome grade. Then the total tractive pull is 2400 lb., including truck and boiler.

A 5-ton truck loaded weighs say 20,375 lb., or 10.187 tons, say 10.2 tons.

On level on hard dirt road the tractive resistance is 100 lb. per ton.

Tractive resistance on a level road 1020 lb.

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The average grade of a country road may be taken as 6% and the force necessary on such a grade with the loaded truck will be $20{,}376 \times .06 = 1225$ lb. off.

Then the total tractive force will be 2245 lb.

The truck carrying its ordinary load is then exerting almost the same pull as the truck hauling the boiler. We think of the latter as an unusual exhibition on the part of a truck. This assumes the same speed. manifestly, the truck on the country road would travel faster. Its "stunt" is then really the greater.

(b) The engineer would need a draw-bar dynamometer and any device for obtaining the speed.

---

399. *Another solution.*

(a)—Truck pulling 43 ton boiler

Assume:

20 lb. per 1000 lb. traction resistance

5 mi. per hour

Level city street

5 T wt. of truck and 3 T wt. trailer

$$HP = \underset{\text{(load)}}{(5+3+43)} \times 2000 \times \underset{\text{(factor)}}{20/1000} \times \underset{\text{(v)}}{88 \times 5/33000} = 27.1 \text{ HP req.}$$

Loaded 5 T truck

Assume:

50 lb. per 1000 lb. traction resistance

10 mi. per hr.

6% grade country road

5 T wt. of truck

(Wind resistance is negligible)

$$HP = (5+5) \times 2000 \times \frac{50}{1000} \times \frac{88 \times 10}{33000} = 26.6 \text{ HP}$$

$$\text{Add for 6\% grade } .06 \times 10 \times 2000 \times \frac{88 \times 10}{33000} = 32.0 \text{ HP}$$

Total 58.6 HP

At 5 mi. per hr. HP is 29.3.

Under either circumstance the "stunt" is greater on the part of the truck on the country road.

INLAND EMPIRE MEETING.

The principal features of the annual meeting of the Inland Empire Council of Teachers of Mathematics were two addresses by Professor Walter A. Bratton of Whitman College and Professor Frank L. Griffen of Reed College. Professor Bratton spoke on, "What a High School Teacher Ought to Know about Einstein," and Professor Griffen on "The Role of Mathematics in Human Progress." Both addresses were followed by spirited discussions.

The Council has been making steady progress since its reorganization three years ago and this meeting was considered the best one yet held. Professor Walter C. Ells of Whitman College who has been President for three years was succeeded in the presidency by W. W. Jones, head of the mathematics department on the North Central High school, Spokane, Wash.

Other officers were elected as follows: Secretary, Miss Christina Claussen, Lewis and Clarke High school, Spokane; Executive Committee, C. A. Isaacs, W. S. C., Pullman, Wash.; Ida A. Mosher, North Central High school, Spokane and J. C. Teeters, Kellogg, Idaho.

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High Schools Again Prepare to Submit Essays in the Annual Good Roads Competition.

For the fourth successive year, high school students of the nation are to be given opportunity to win the largest single educational award offered in the United States, according to a statement by the Highway Education Board today.

The award is the H. S. Firestone Four Years University Scholarship, providing not only tuition, but room, board, books, and special fees for the student writing the best essay in the annual good roads essay contest. The assigned subject of the essays to be written is "The Influence of Highway Transport Upon the Religious Life of My Community."

Announcement of the contest is being made to superintendents of schools, high school principals, and students as rapidly as possible, and all available literature is being listed and tabulated for the information of the prospective contestants. The Board announces its willingness to answer any inquiry students and teachers may desire to make, but it points out that all that is necessary is compliance with the simple rules of the contest, and the preparation of a 700 word essay on the subject. Essays should be submitted to the high school principal by May 1.

The contest, known to thousands of students throughout the United States and territorial possessions as the "annual good roads essay contest" is the most sustained competition of its kind. Inaugurated in 1920, it has provided a college education for three students, one boy and two girls, and its maintenance from year to year is assured by the donor of the scholarship, Harvey S. Firestone, Akron, Ohio.

This year the subject is regarded as unique and unusual, bringing up for discussion the relation of improved transportation to the moral tone or the religious life of the community. Leading churchmen have expressed their approval of the discussion the essays are to bring about, while distinguished educators have given their approval to the contest itself. In past years the subjects have been broader, and more general, the subject for 1922 dealing with the improved transportation and the growth of the community as a whole.

Previous winners have been Miss Katharine F. Butterfield, Weiser, Idaho, 1920; Miss Garland Johnson, Bridgeport, West Virginia, 1921, and in 1922, Karl G. Pearson, Washington, District of Columbia. Miss Butterfield is in college, but Miss Johnson and Mr. Pearson, not being seniors when the scholarship was awarded them, have remained in high school until their courses are completed. They both will enter college this year, Miss Johnson at the University of West Virginia, and Pearson at a university in Kansas, his home state.

The best three essays from each high school are to be submitted to state headquarters, where the best essay from the commonwealth will be chosen. One essay from each state and territory will then come to the Board at Washington, D. C., there to be handed a national committee to be named by Dr. John J. Tigert, U. S. Commissioner of Education. The national committee will award the scholarship.

Inquiries should be addressed to the Highway Education Board, Willard Building, Washington, D. C.

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SOUTHERN CALIFORNIA MEETING.

Despite inclement weather about sixty members and friends of the Southern California Science and Mathematics Association met Saturday, March 3, 1923, at the Southwest Museum.

President Leroy S. Weatherby introduced Dr. John Comstock, Director of the Museum, who spoke most interestingly on the Researches and Facilities of the Museum. His talk was illustrated by some beautifully colored slides of the Museum and those of its treasures to which he wished to call the special attention of the visitors. Following the lecture and business meeting was an inspection of the Museum under the direction of Dr. Comstock and staff.

The report of the Secretary-Treasurer was accepted as read.

President Weatherby announced that Mr. Sandifur and Mr. Fluckey were the committee appointed to confer with those on the Program Committee choosing speakers for institute, with instructions to try to have one or more really scientific speakers on next Institute's program.

Miss Willson reported that the Physics-Chemistry section planned a trip to Covina some time in May to visit the cement process plant, and that Mr. Ross had asked them to be his guests while in Covina.

Mr. Cookman reported plans afoot for a biology section meeting with Professor Loye Miller of the University of California to study the fossil birds of the La Brea pits; also plans for some field trips for bird study.

The President appointed Miss Willson, Mr. Enochs, and Mr. Mitchell as a committee to see if something could be done to arrange with the proper authorities for excusing science teachers at the time of the national meeting of the American Association for the Advancement of Science to be held in Los Angeles immediately following the total eclipse of the sun next September.

President Weatherby also appointed the officers of the sections as a committee, to associate other members with them, to review new science books and recommend to the public library the purchase of suitable books. Miss Ralph moved, and the motion was duly seconded, that this committee might draw upon the treasurer for a "reasonable amount" necessary to carry on this work.

Mr. Hanna of Los Angeles High School presented an invitation to the association to hold the May meeting at Los Angeles High School, and he said the different departments were planning original demonstrations for the afternoon section meetings. The invitation was accepted.

Mr. Hanna, speaking for the American Chemical Society, also invited the Association members to attend the Society's meetings on March 15 at the Mary Louise Dining Room at 6 p. m., when Dr. Franklin, National President of the Society, will talk upon Reactions of Aqueous Solutions of Ammonia; and on the last Friday night in April at Los Angeles High School at 6 p. m., when Dr. Darwin will give a lecture of interest to biologists concerning experiments based upon bacteriological-chemistry.

There being no further business, the meeting adjourned.—[Grace M. R. Abbot, Secretary-Treasurer.

BOOKS RECEIVED.

Essentials of Geometry, by David Eugene Smith, Columbia University. Pages VII. 296. 13.5x19 Cen. Cloth. 1923. $1.24. Ginn & Co., Chicago.

Plane and Solid Geometry, by Walter B. Ford, University of Michigan, and Charles Ammerman, McKinley High School, St. Louis. Edited by E. R. Hedrick. Pages 10. 356. 28.13x19 Cen. Cloth. 1923. Macmillan Book Co., New York City.

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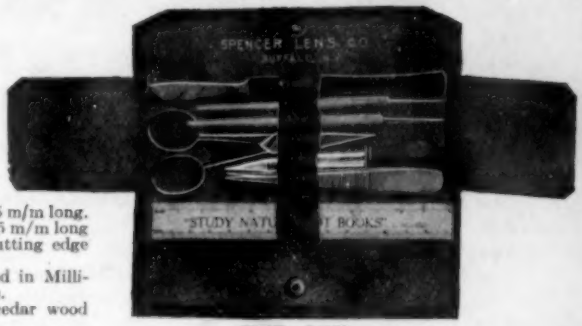

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Elementary and Organic Chemistry, by W. H. Barrett, Harrow School, England. Pages 13x19 Cen. Cloth. 1923. $1.50 Oxford University Press.

Biology of Home and Community, by Gilbert H. Trafton, Teachers College, Mankato, Minnesota. 13x19.5 Cen. Cloth. 1923. Macmillan Book Co., New York, N. Y.

Letters of a Radio Engineer to His Son, by John Mills, Western Electric Company, 265 Pages. 14x20½ Cen. Cloth. 1922. Harcourt Brace and Company, New York City.

The Menace of Morphine, Heroin and Cocaine, by Montaville Flowers and H. R. Bonner. 47 Pages. 15x22½ Cen. 1923. Narcotic Education Association, Pasadena, California.

The Reorganization of Mathematics in Secondary Education, a report by the National Committee on Mathematical Requirements under the Auspices of the Mathematical Association of America. Pages XI+652. 15x23 cm. Paper. 1923.

The Mathematical Association of America, Dartmouth College, Hanover, N. H.

The Quantum Theory, by Fritz Reiche, University of Breslau, translated by H. S. Hatfield and Henry L. Brose. 15 diagrams. 183 pages. 13x19.5 Cen. Cloth. 1922. $2.50. E. P. Dutton and Company, New York.

Automotive Manual, by Albert L. Taylor and H. Blake, University of Utah. Pages VII+178. 15.5x23.5 Cen. Paper. 1923. Macmillan Company, New York City.

Plain and Solid Geometry, by Herbert E. Hawkes, Columbia University, William A. Luby, Junior College of Kansas City, and Frank C. Touton, University of California. Pages VII+496. Cloth. 1923. $1.60. Ginn and Company, Boston, Mass.

A Little Book on Water Supply, by William Garnett, St. John's College, Cambridge. Pages XV+144. 15x22 Cen. Cloth. 1922. Cambridge Eng. University Press.

Health, Public and Personal, by Ralph E. Blount, Waller High School, Chicago. Pages X+316. Cloth. 1922, Allyn and Bacon, Chicago.

Introduction to Plane Analytical Geometry and Differential Calculus, by Clifford N. Mills, Heidelberg University, Tiffin, Ohio. Pages XI+131. Cloth. 1922. $1.50. P. Blackiston's Son and Company, Philadelphia.

Geology and Mineral Resources of the Morris Quadrangle, by Harold E. Culver. Pages 114, 17x25 Cen. Paper. 1922. University of Illinois Press, Urbana.

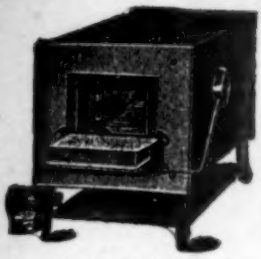
Rapid Arithmetic, by T. O'Connor Sloane. Pages VIII. 190.13x19 Cen. Cloth. 1922. $1.50 net. D. Van Nostrand Co., New York City.

Agriculture for Southern Schools, by John F. Duggar, Alabama Polytechnic Institute. Pages X+369. Cloth. 15x19 Cen. 1923. Macmillan Co., New York City.

General Science with Experimental and Project Studies, by Garfield A. Bowden, University School, Cincinnati. Pages VIII+634. 22x14 Cen. 334 illustrations. Cloth. 1923. P. Blakiston's Son & Company, Philadelphia.

Plant Physiology, Vladimir I. Palladin, University of Petrograd. Edited by Burton E. Livingston, John Hopkins University. Pages 33+360. 16x19 Cen. 173 illustrations. 1923. $4.00 net. P. Blakiston's Sons & Company, Philadelphia.

Four Lectures on Relativity and Space, by Charles P. Steinmetz, American Institute Electrical Engineers. Pages 10+126. 15½x18½ Cen. Cloth. 1923. McGraw-Hill Book Company, New York City.



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Biology in the Public Press, by Charles W. Finley and Otis W. Caldwell, Teachers College, Columbia University. Pages V+151. 13x15 Cen. Paper. 1923. Lincoln School of Teachers College, New York City.

Essentials of Geometry, by David Eugene Smith, Columbia University. Pages VII. 296. 13.5x19 Cen. Cloth. 1923. $1.24. Ginn & Co., Chicago.

Plane and Solid Geometry, by Walter B. Ford, University of Michigan, and Charles Ammerman, McKinley High School, St. Louis. Edited by E. R. Hedrick. Pages 10, 356. 28. 13x19 Cen. Cloth. 1923. Macmillan Book Co., New York City.

Elementary and Organic Chemistry, by W. H. Barrett, Harrow School, England. Pages 13x19 Cen. Cloth. 1923. $1.50. Oxford University Press.

Biology of Home and Community, by Gilbert H. Trafton, Teachers' College, Mankato, Minnesota. 13x19.5 Cen. Cloth. 1923. Mac Millan Book Co., New York, N. Y.

Seventh Year Book, National Association of Secondary School Principals. Edited by H. B. Church. Pages liii+150. 16x24 Cen. 1923. Published by the Association.

BOOK REVIEWS.

Text Book of Anatomy and Physiology, by Elizabeth R. Bundy, late Adjunct Professor of Anatomy, Woman's Medical College of Pennsylvania. Fifth edition, revised and enlarged by Martha Tracy, Woman's Medical College of Pennsylvania, and Grace Watson, Philadelphia General Hospital Training School for Nurses. Pages xv+442. $2.50. P. Blakiston's Son & Co., Philadelphia.

The authors of this volume have succeeded admirably in the attempt to produce a brief, yet comprehensive text-book of human physiology, together with the necessary background of anatomy. The work is clear, concise, and especially noteworthy in the psychological method of presentation. Of the 266 figures, forty-six are in colors where these are necessary to elucidate the text. The book has been brought up-to-date so as to include facts which are the results of the latest research, insofar as this is possible in a brief treatise. The practical notes which are scattered through the book add to the value of the work from the points of view of interest and utility. The book should prove an excellent text for use in training schools for nurses, the purpose it was originally intended to serve. It should prove equally useful in teacher training classes in physical education. The fifth edition has been improved with an evident view to meeting the needs of general normal school and college use. The book should be in the hands of teachers of biology in all grades of schools.

J. C. I.

The Quantum Theory, by Fritz Reiche, University of Breslau, translated by H. S. Hatfield and Henry L. Brose. 15 diagrams, 183 pages, 13x19.5 Cen. Cloth, 1922. $2.50. E. P. Dutton and Company, New York.

This is a convenient summary of the theory of quanta which has occupied so large a share of attention in recent physical theory. It sketches the development and explains the general character of that theory in a way which would be difficult to excel. A clear and vivid style of exposition is plainly guided by a quiet enthusiasm for this fascinating subject; but there is no lack of objectivity in pointing out gaps and drawbacks and naming problems that need attention. This critical feature, worked in with both candor and fairness, is especially attractive. The range of topics is as wide as could well be expected in a book with its motive.

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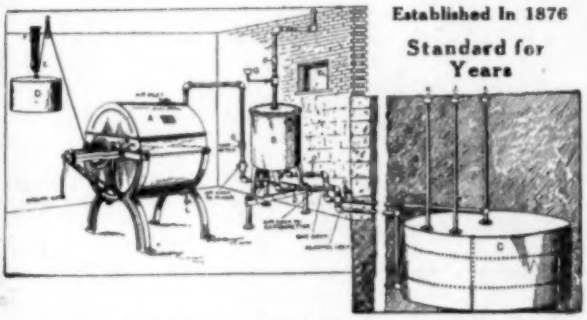

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The translation is such that one would hardly from internal evidence guess it to be that. A. C. Lunn.

General Science, by Garfield A. Bowden, University School, Cincinnati. Pages VIII+634. 334 illustrations. 10½x22½ Cen. Cloth. 1923. P. Blakiston's Son & Company, Philadelphia.

This is one of the very latest texts in this very popular subject that has come from the press, and the reviewer must say that it is one of the most interesting that has come to his desk. Of course, there is much more matter in the book than can be used in the time alloted for instruction in general science. Yet, this is a fine fault, if it is a fault, due to the fact that it gives the instructor an opportunity to select material which he thinks will best meet the conditions of his class. It is a text that is written in such a clear and forcible way that the boys and girls who are studying the subject will take very kindly to the subject. The purpose of each exercise or project is to present a method which will cause the pupil to appreciate it. The book endeavors to cause the pupil to think and to work out the various exercises himself. The book deals with man especially. The illustrations and drawings have been selected with utmost care, in order to present, in a very forcible way, the subject talked about. The pages devoted to the very sciences are as well distributed as could be expected. There are many exercises, to be carried out by the pupil, scattered throughout the book. Main paragraphs begin with bold-faced type. It is printed on splendid paper which is not too glossy. It is a book well worth the consideration of any school about to adopt a general science text. Mechanically, the book is well made. C. H. S.

The Menace of Morphine, Heroin and Cocaine, by Montaville Flowers and H. R. Bonner. 47 Pages. 15x23 Cen. Paper. 1923. 25c. International Narcotic Education Association, Pasadena, California.

This is a very timely pamphlet which is based upon an extensive survey of text bearing upon this subject including a great number of physiologies used in the public schools and a text of leading medical colleges. It gives the essentials of what every man, woman and child ought to know concerning this matter. If there was an opportunity to place an entering wedge into the curricula of our high schools in this matter, no text could is better than the one here described. The use of these drugs is beyond the comprehension of an ordinary American citizen. It is getting hold of thousands of our youths, bringing them to an untimely death. Let the good work go on until the abominable things are entirely exterminated. C. H. S.

Seventh Year Book, National Association of Secondary School Principals. Edited by H. B. Church. Pages liii+150. 16×24 Cen. 1923. Published by the Association.

This is a very comprehensive report of the transactions of this very valuable and active association. It contains the essential parts of the transactions of the recent meeting. A splendid table of contents is given. The officers of the association are also named, together with a directory of the membership which in itself is immensely valuable. The constitution of the association is also printed. No secondary school principal ought to be without a copy of the book. C. H. S.

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The Automotive Manual, by Albert Taylor and H. Blake, University of Utah. Pages VII+178, 15.5x23.5. Cen. Paper, 1923. Macmillan Company, New York City.

There have been many books recently written bearing upon the subject-matter as indicated in the name of this book, but the writer has not been able to find one more comprehensive, more clearly written, and more up-to-date than this particular book. It is one that all automobile owners and drivers ought to own in order to familiarize themselves with the working parts and operations of the particular car which they may be driving. The principles of the machinery used in the car are clearly brought out in the discussions. It is clearly written, the diction is fine and it makes good reading. There are thirty-six chapters, each chapter closing with a list of questions bearing upon the work discussed in that chapter. Also, there is an experiment given at the end of each chapter, which if carried out will surely familiarize the student with the discussion that has taken place. Major paragraphs all begin with bold-faced type which indicates the subject-matter discussed in those paragraphs. It would be a wonderful help to any one who wishes and hopes to do repairing on his injured automobile. There are sixty-four well selected cuts. It is well indexed and the writer speaks for a large sale of this particular book.

C. H. S.

Health, Public and Personal, by Ralph E. Blount, Waller High School, Chicago. Pages X+316. Cloth. 1922. Allyn and Bacon, Chicago.

This book comes from the press at a most favorable time in its endeavor to promote the health of people and communities. Any one reading the book cannot help but be impressed with the desire to do more than they have been doing in order to keep themselves physically fit. Functions of the body are discussed in a very satisfactory manner. Various topics discussed are treated in a very simple way and made very practical and interesting. Effort has been made to furnish that material which will enable the pupil or reader to protect his own as well as the health of the community in which he lives. It is written in a very clear and concise manner. There are seventeen chapters and 151 half-tones in drawings selected for their worth in illustrating the topics discussed. It is a book that should be in the hands of every person interested in civic matters. It deserves a large circulation and, doubtless, will have the same.

C. H. S.

Seventeenth Annual Report of the Carnegie Foundation for the Advancement of Teaching by the Officers. Pages VII+211, 19x25 Cen. Paper. 1922. Merrymount Press. Boston.

Another very comprehensive report of the Carnegie Foundation is at hand, and for educators who are interested in this foundation they will find it a most comprehensive and intelligent report.

It tells of the total sum paid by the foundation in retiring the allowances and pensions, giving various institutions that come under the benefits of it and the total amount of money that men from these institutions have received. The total amount of resources of the foundation are given together with the securities that they own. There is a chapter on the study of "Dental Education" which the foundation is undertaking. Also one on the study of "Training of Teachers." Extensive comment is made on legal education. This foundation has had no small influence in increasing the qualification for admission to the American bar. The development of the pension plans is discussed and developed to some considerable length.

C. H. S.